Chemical & Process Engineering

A monthly international review of chemical plant and operations for all industries

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LEONARD HILL LIMITED, STRATFORD HOUSE, 9 EDEN STREET LONDON, N.W.1

VOL. 34, NO. 1. Pages 1-32

JANUARY 1953

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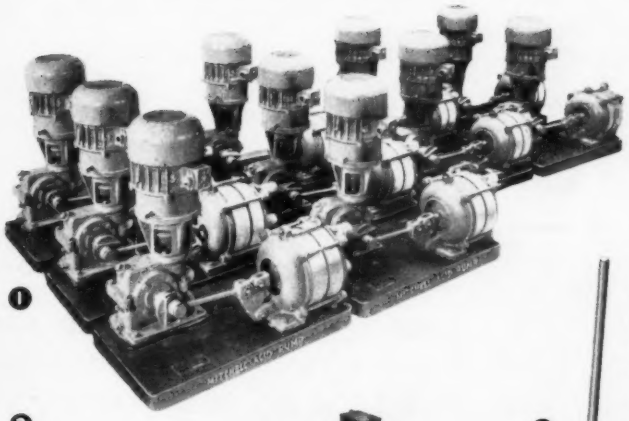

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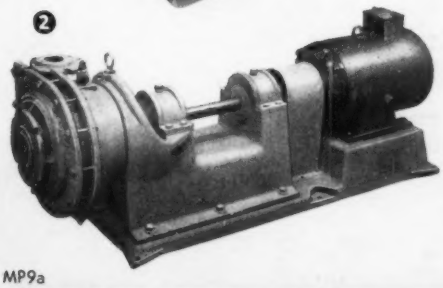

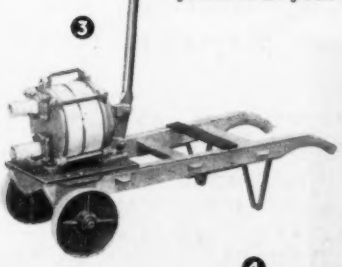

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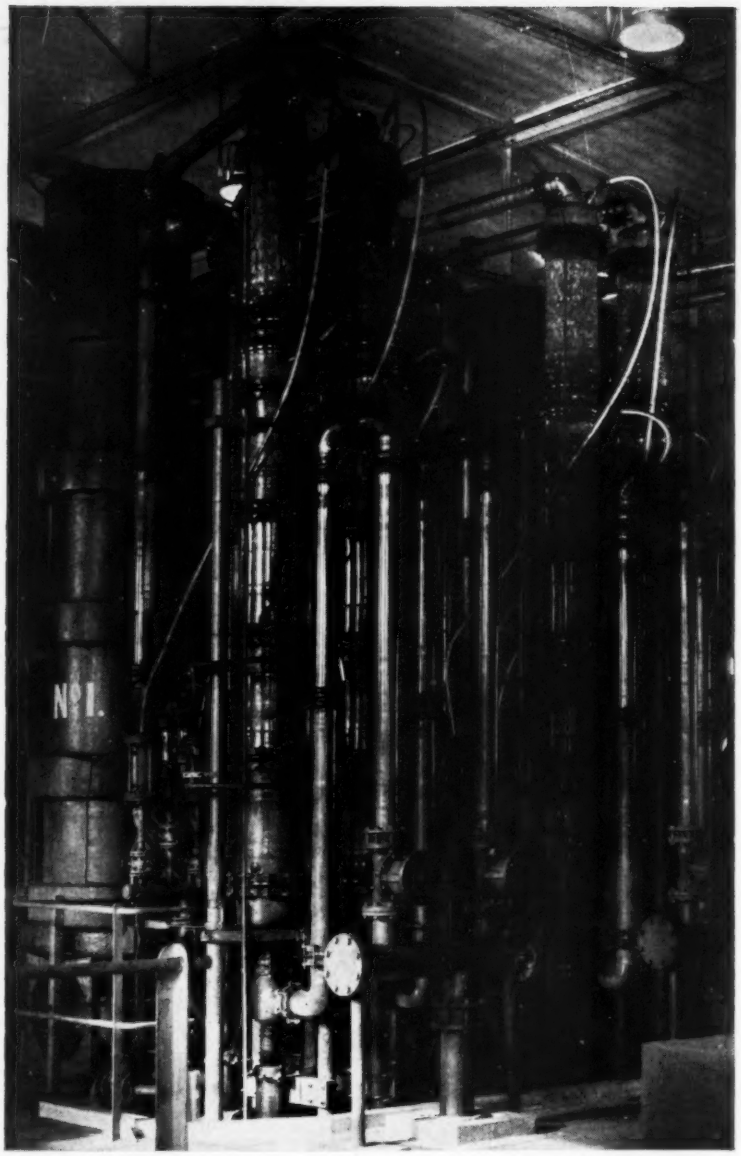

Hydrochloric Acid Absorption Towers
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Subscription rates: 1 year 6 dollars, 3 years 15 dollars, paid in advance

England: Leonard Hill Limited, Stratford House, 9 Eden Street, London, N.W.1 *U.S.A.: British Publications Inc., 150, East 35th St., New York, 16*

Topics of the Month

New centres of American chemical industry

THE record $6 billion expansion now taking place in the Unites States' chemical industry is rapidly moving the centre of the industry southward and westward. A study by the Manufacturing Chemists' Association Inc. reveals that, while all sections of the country have participated in the tremendous growth of the industry over the past two years, a majority of the new chemical plants have gone up in the south, particularly in the states bordering the Gulf of Mexico, and in the middle west.

The industry is approaching the halfway mark in its $6 billion expansion programme for the five years 1951-55. This programme will mean roughly a one-third increase in the size of the 1950 chemical industry and comes on top of a war-time expansion estimated at $3.5 billion and a post-war expansion of about $5 billion. The current programme will add more than 200,000 employees to chemical industry payrolls.

Plastics, synthetic fibres, detergents and agricultural and medicinal chemicals will account for much of the growth. Among basic industrial chemicals, there will also be substantially increased output of chlorine, alkalis and ammonia.

The expansion is among the largest ever undertaken by a manufacturing industry, according to the M.C.A. chairman, Mr. Wm. H. Ward. As such it has raised some major financing problems, necessitating the sale of a record amount of new chemical company securities in addition to use of depreciation reserves and profits. Declining chemical industry profits caused by rising taxes and other costs since 1950 have complicated the problem.

The M.C.A. study is based to a substantial degree on an analysis of rapid amortisation certificates for 789 chemical and allied projects issued by the Defence Production Administration up to last October. There are many other expansion projects in the chemical industry for which no rapid amortisation certificates were granted. Conservative estimates place the expansion covered by certificates at less than 70% of the total for the industry.

Although certificates have been issued for chemical projects in 45 out of the 48 states, plus Hawaii and Alaska, the greatest expansion has taken place in the west-south-central region comprising the states of Texas, Louisiana, Oklahoma and Arkansas. According to the M.C.A. study, this area has a total of $706,344,000 in new plants covered by certificates. This is almost twice the next largest total of $372,888,000 for the east-north-central states of Ohio, Indiana, Illinois, Michigan and Wisconsin.

Both these figures represent a major trend southward and westward from the middle Atlantic states, traditionally the leading chemical-producing area of the country. The

middle Atlantic region ranks fourth in the current expansion with a total of $296,605,782 in new plants.

Figures for other regions are: south Atlantic, $298,070,968; east-south-central, $198,512,000; Pacific, $136,532,000; west-north-central, $102,856,000; mountain, $73,986,332; and New England, $31,313,000. Among individual states, Texas leads the nation with projects totalling $435,088,000. Louisiana is second with $202,859,000 and Michigan third with $150,760,000.

The principal reason for the large concentration of new chemical activity in the south-west has been the combination of readily available raw materials, particularly petroleum and natural gas, plus low-cost water transportation to eastern markets. Most of the expansion in the area has been in ammonia for synthetic fertilisers and explosives, and in plastics and synthetic fibres, all from petroleum or natural gas.

Much of the middle-western expansion has also been in petroleum chemicals, partly based on local gas fields and partly on gas brought in from the south-west by pipeline.

The study shows that the largest single dollar value certificate issued for a chemical project by the Defence Production Administration is an $88 million plant to produce nylon fibre at Pensacola, Florida. Other major projects include a $66 million plant to make ethylene oxide and polythene at Seadrift, Texas; another $36 million polythene plant at Torrance, California; a $44 million plant to produce petrol anti-knock fluid at Houston, Texas; and a $30 million synthetic ammonia plant at New Orleans.

Surface-active agents and fertiliser conditioning

NO one in the fertiliser industry takes lightly the problem of caking or setting. To keep naturally hygroscopic materials in a free-flowing condition even when final use on the farm may be preceded by several months' storage is a far from simple task. In Britain it has been solved for mixed fertilisers and *Nitro-Chalk* by granulation, but even today Britain is the only country where a predominant portion of fertiliser production is granulated. Apart from granulation, the only general conditioning process has been the use of a bulky diluent, though for certain 'straight' fertilisers crystal-shape modification has been successfully introduced. However, there are now strong indications that an entirely new approach to the problem is possible—the use of modern surface-active chemicals. A recent report from the United States reveals that several manufacturers of compound fertilisers are using the proprietary substance, *Santomerse* 1, an alkyl aryl sulphonate. Only 1 lb. is added to 1 ton of the dry 'mix.' As is well known, the normal procedure is to allow the mixed materials to stay in a heap until a hard set has developed; the lumpy or even cement-like mass is then milled. The period of 'curing' may be as long as three to six weeks, though this time is safely reduced if a bulky conditioner is adequately present. It is said that the presence of 0.05% surface-active chemical reduces curing time from thirty to three days and gives a final product that can be stored for long periods without fear of further setting or caking.

In addition, there is news (*Indus. & Eng. Chem.*, 1952, **44**, (11), 2663-2667) of a not dissimilar development to overcome the awkward caking habit of ammonium nitrate in the explosives industry. Here I.C.I. research has led to the use of a crystal-modifying dye, acid magenta, 0.03% of which controls the natural caking tendency of this physically troublesome material. However, to increase the anti-caking effect, especially above 32°C., 0.003% of a surface-active agent is also added. It may not be just a coincidence that acid magenta, the most effective of several crystal-modifying dyes, is a tri-sulphonated substance; powerful surface-activity is at any rate suggested by this.

The caking of hygroscopic chemicals is due to the formation of films of saturated solution which become concentrated by capillary forces between particles; any change in environment that initiates crystallisation then turns these films into an interlocking 'cement.' It would seem, therefore, that suitable surface-active agents, by reducing capillary forces, prevent the widespread formation of these films of solution. If such small proportions of surface-active substances are effective, this new method will not be too costly for fertiliser economics; indeed, it should be cheaper than the use of 1 or 2 cwt. per ton of conditioners and perhaps even cheaper than granulation.

African aluminium

THE Volta River Aluminium Scheme which we discussed in these notes last August (p. 420) is the subject of a recent Government White Paper. As described, the project is very attractive. About 75 miles from its mouth the Volta passes through a range of hills and the gorge formed is suitable for a high dam and a resultant hydroelectricity generating station. Twelve miles away there is a suitable site for an aluminium smelting works, and this point is only 30 miles from the coast. There are two large bauxite deposits not far away with reserves that would last at least 200 years. The world demand for aluminium is steadily rising, but at present production is heavily concentrated in the United States and Canada. Although Britain has an aluminium industry in Scotland, four-fifths of her needs must be imported and almost every ton that comes from abroad costs dollars. It is reliably predicted that by 1975 Britain will need at least three times as much aluminium as she is now consuming. An American examination of the future of aluminium is less cautious, world demand in 1975 is estimated to be four or five times the present level. With all these pointers to success, it is difficult to see how the Volta River plan for founding an aluminium industry in the Gold Coast can possibly fail.

The capital needed for the initial development is £100.5 million. This would provide an annual capacity of 80,000 tons of aluminium. Further capital outlay, making the total investment £144 million, would lead to an eventual output of 210,000 tons p.a. Britain's proposed share in the provision of capital—£43.3 million rising to £56.8 million—will surely be a fair bargain, since it will carry the condition that three-quarters of the output must be offered to U.K. buyers at sterling equivalents to prices ruling in Canada or America. A sterling source of aluminium with an eventual capacity that is rather more than half the current Canadian output and at least seven times the Scottish output is clearly much more than 'just another Colonial development scheme.' It is the kind of project that the sterling Commonwealth area must undertake with all possible swiftness. In the long run an aluminium industry based upon adjacent bauxite as well as upon hydroelectricity is likely to have significant economic advantages. The Canadian industry has always been based entirely upon imported bauxite and, although bauxite is mined in the United States, the American industry is also heavily based upon imports.

Pioneer metallurgist

PLATINUM was discovered in 1735, but it was not until the middle of the next century that it was successfully refined and manufactured on a commercial scale. In 1809 a large sulphuric acid boiler weighing 322 oz. was made in platinum in England and a large platina alembic for sulphuric acid and with a capacity of 250 pints as well as a platina distillation unit for hydrofluoric acid were shown by a French company at the 1851 exhibition. Six years earlier, Percival Norton Johnson had produced a 60-oz. platinum ingot for the first time and, by 1854, 500- and 1,000-oz. ingots were being produced at his Hatton Garden works.

Platinum pioneer, Percival Norton Johnson, founder of Johnson, Matthey & Co. Ltd., was born in 1792. He was the eldest son of John Johnson, himself a metallurgist and at one time the only commercial assayer in London. After working with his father, he established himself in Hatton Garden in 1818. The company was not known by its present name until 1851, when two members of the Matthey family joined as part of an earlier financial agreement.

Accuracy was the keynote of Johnson's work and the origin of his refining business, which is now the largest of its kind in the world, was his willingness to buy all bars of gold and silver which were refused by the buyers of bullion, upon his own assay. When gold bars from the Brazilian 'Gongo Soco' Mines were imported in large quantities, they were refused at the Mint on account of brittleness. Johnson was consulted and undertook to refine and toughen them. He succeeded, and the whole of the Brazilian gold was from that time worked at Hatton Garden. In this gold he discovered the existence of palladium and, having succeeded in its separation, he introduced it commercially, at once determining and making known the best uses to which it could be applied. At one time he was able to supply it at 14s. per oz.!

After he had been in business some time he visited Germany, where he met with the compound alloy, German silver (also known as nickel silver or British plate). He brought back some of the metal, analysed it and commenced manufacture. He was the first person in England to make it and his claim to be the first person in England to refine nickel is also associated with this work.

It was about this time that he was engaged in many mining pursuits and visited professionally nearly all the mines in Great Britain and many of the foreign ones. He was the first to introduce in Cornwall the German shaking, jigging and washing table with important improvements of his own, and was a pioneer of miner's welfare, erecting schools and houses and doing much to alleviate the toil of the work.

Among his minor inventions may be mentioned several pottery colours, for instance 'rose pink,' which was very much in demand in the Potteries at that time, and 'oxide uranium,' a valuable colour in glass making.

Johnson died in 1866. It is only possible to record here a few of his major contributions to the metallurgical sciences and industrial welfare. However, the chemical engineer or industrialist interested in the history of metallurgy will find many more details in a comprehensive biography, *Percival Norton Johnson*, which has been written by a director of Johnson, Matthey, Mr. Donald McDonald. This handsome volume consists of 224 pages, including appendices. It is fully illustrated and bound in half leather.

'FIBRES—Natural and Synthetic'

WITH the present (January) issue, our associated journal *Textile Industries and Fibres*, published by the Leonard Hill Technical Group, changes its name to *FIBRES—Natural and Synthetic*. The change has been made following a survey of fibre-producing and -using countries, and in order to maintain the Leonard Hill tradition of publishing technical journals which apply chemistry and science to industry.

The new journal will cover the production and use of all natural and synthetic fibres for the manufacture of textiles and other fibre products. Greater emphasis will be given to scientific developments and the use of chemicals in the fibre industries. There will be reports of new materials, chemical applications, machinery, research and methods of laboratory, factory and mill practice.

Regular features will include 'International Digest,' 'News' and 'World Markets.' The size of the journal has been enlarged to 12 in. by 9 in.

Volume dilatometry

SCIENTISTS of the U.S. National Bureau of Standards have found the simple, inexpensive volume dilatometer to be a valuable research tool for obtaining data on volume co-efficients of thermal expansion and for studying phase changes in solids and liquids. Continued application of volume dilatometry at the Bureau over the past 15 years has resulted in improvements in technique and in simplification of the apparatus to such an extent that accurate dilatometers can now be made and used in almost any small laboratory.

Linear dilatometers of various types have frequently been used to advantage in determining the expansivity of metals and other solid materials. They cannot, of course, give correct results for liquids or for other fluid materials. In these cases the volume dilatometer can be used successfully; it has been shown to have a precision of about 1%.

Primarily, the volume dilatometer measures the change of volume of a sample as it undergoes a change in temperature. Its secondary importance lies in the discovery of phase-changes and other transitions. Thus, if the density or volume of a substance is plotted as a function of the temperature, there will be anomalies in the otherwise smooth curve wherever there is a change of phase or other transition. These anomalies represent points at which a change occurs in the structure of the sample or in the types of motion by which it can absorb energy. They may or may not be accompanied by the release or absorption of heat.

Materials for constructing the instrument consist of glass tubing of any convenient size and a calibrated glass capillary. The confining liquid may be mercury or any other substance which has a known expansivity and which will not react with the sample. Uniform heating is provided by means of a bath containing alcohol, water, or high-boiling oil, depending on the range of temperature to be studied.

The preparation and operation of the volume dilatometer may be described briefly as follows: A glass capillary is carefully calibrated and sealed to one end of a larger glass tube. The weighed sample is introduced into the tube, a glass bulb is added, and the tube is sealed. The bulb is used to prevent overheating of the sample during the sealing operation. The dilatometer is then weighed, evacuated, filled with mercury, reweighed, and then placed in a bath. As the bath is heated, the sample expands, forcing mercury up into the capillary where readings may be made. From

the known weights and densities of the sample and the confining liquid and from the known expansivity of the confining liquid, the expansivity of the sample can be calculated. Corrections must be applied for entrapped air bubbles, non-uniformity of the capillary, and the thermal expansion of glass.

Stronger cast irons

AS the culmination of long proceedings before the Patent Office and the Patents Appeal Tribunal, the Mond Nickel Co.'s British Patent No. 630,070, covering the production of spheroidal graphite cast iron by the magnesium process, has now been granted. The process, it is claimed, provides a range of cast irons with double the strength of all previous known types and eliminates the brittleness normally associated with iron castings. These irons are important to designers in all branches of engineering.

The application for this patent was made in March 1947 and in May 1948 the first public disclosure of the process was made simultaneously in Great Britain and the U.S.A.

In October 1949 the application was accepted by the British Patent Office, and published. Opposition to grant of the patent was lodged by the Meehanite Metal Corporation on the grounds that the invention had been disclosed in certain prior publications and that the nature of the invention and the manner in which it is to be performed was not sufficiently and fairly described in the specification.

In June 1952, after protracted proceedings, the Patent Office gave its decision agreeing to seal the patent. Appeal against the decision was made to the Patents Appeal Tribunal and the hearing before this tribunal took place on November 10-12, 1952, when Mr. Justice Lloyd-Jacob directed that the patent should be granted.

This final decision clarifying the patent position will be particularly welcome to the numerous licensees of Mond Nickel who are actively engaged in the manufacture of spheroidal graphite cast iron by the magnesium process. Similarly for engineers it will remove all doubts about the sources of supply of this material.

Deville's centenary

FEW people will realise that the initiation of the Gold Coast aluminium project marks the centenary but for a year of the first production of sizeable pellets of aluminium by a process which was the forerunner of a commercial one. And how many will connect the name of the chemist, Henri Sainte Claire Deville, with this centenary?

Let us give some small recognition to this centenary and to the man by recalling that Deville was born on March 11, 1818, at St. Thomas, in the West Indies, where his father was French Consul. Henri and his elder brother Charles were both educated in France at the Collège Rollin, and Henri continued his chemical education under a series of distinguished chemists, including Thenard and J. P. A. Dumas. In 1851 he succeeded Balard (the discoverer of bromine) as professor of chemistry at the Ecole Normale. It was there that he started to look for a commercial method of preparing aluminium.

The element had been known since 1827, when Wohler had prepared it as a grey powder by the action of potassium on aluminium chloride. In January 1854 Deville improved Wohler's method so as to get small beads of the metal, enough for him to find out its properties and, as he put it, to 'understand how such a metal could be used, if only it could be easily obtained.' Later in the same year, both he and Bunsen succeeded, independently, in preparing aluminium by electrolysis, but this process was too expensive in an age without dynamos, and Deville returned to the chemical method for his commercial attempt. He was now financed by Napoleon III, to whom he had presented an aluminium medal, and who had visions of light-weight helmets and armour. Napoleon III eventually owned an aluminium dinner service which he rated far above his gold one, a reflection that strikes a somewhat ironic note nowadays.

Deville's industrial process, set up at Glaciére and later moved to Naterre, used sodium as the reducing agent, and this was the method used by the first British manufacturers at Battersea in 1859. Electrolytic processes were not really commercially possible until 1886, when Charles Hall and Paul Héroult invented, simultaneously and independently, their cryolite-using process.

Deville's other work included the preparation, in 1858, of artificial jewels, using an oxy-hydrogen flame, the discovery of toluene in 1841, and the discovery of nitric anhydride. In 1859 he became a professor at the Sorbonne. He died on July 1, 1881, too early to see the world of high-speed travel and modern architecture that his metal had done so much to make possible.

Ten-second paint drying process

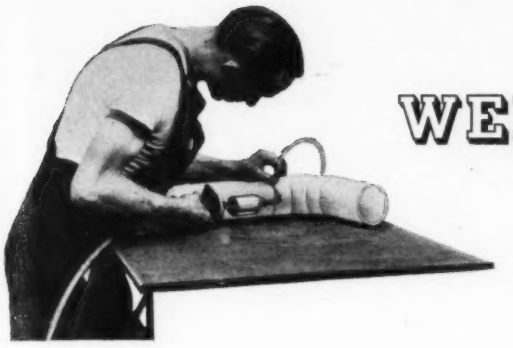
SULPHUR dichloride vapour is the active agent in a new process for drying paint, ink or varnish coatings. The mechanism involved is that of chemical reaction rather than by the polymerisation or evaporation of solvents. In this new process, dry sulphur dichloride vapour generated by passing low-pressure air through liquid dichloride is blasted or sprayed on to the coated side of the material as it passes through the treating chamber, causing a rapid chemical reaction between the sulphur dichloride and the oil. It is thought that with unsaturated oils the dichloride probably causes polymerisation by acting on the double bond, and with unsaturated compounds it probably takes the place of a hydrogen atom in the hydrocarbon. In either case, the reaction is said to give a relatively dry, hard film or deposit within about 2 to 10 sec. for unsaturated hydrocarbons and 30 sec. or less for saturated compounds.

As residual dichloride vapours might damage the material, they are removed in a deodorising chamber by blasts of dry air, which are then passed through a water scrubber. The chloride is broken down by water into hydrogen chloride and colloidal sulphur, so that the exhausted air is free of dichloride vapours. In principle, therefore, the process is simple, and requires no heat or solvents, but the technique would appear to be unsuitable for certain processes that require humidity control to get exact register for many coatings on sheets of large size. Apart from these, however, there are many applications where the process might be used, and if the claims that have been made are justified, the development may well have far-reaching effects on future methods of drying or hardening coatings.

'CPE'—February

Articles next month will include :

'Chemical Engineering Review—Filtration'; 'Future of Petroleum Processing'; 'Rates of Drying in Tray and Rotary Driers'; 'Synthetic Liquid Fuel Plants.'



WELDING POLYTHENE AND PVC

By C. Fisher, B.Sc.(Eng.), A.C.G.I., D.I.C.

Polythene and polyvinyl chloride (PVC) were originally developed for use in the electrical industries. Subsequently it was found that these materials, as well as possessing high dielectric properties were also resistant to corrosion by many acids and alkalies. Many applications have since been found for them in chemical, pharmaceutical, oil, food and beverage processes plants, where resistance to corrosion and durability of vessels are vital considerations. The value of a material commercially is governed to a great extent by the facility with which it can be worked. Polythene and PVC can be manipulated with ease. The materials, which are commonly manufactured in sheet or tubular form, can be cut, machined, spun, drawn, pressed, extruded and welded. In the chemical engineering industries, the weldability of a material is of importance and it is necessary to develop welding methods which can be employed in the fabrication of the many items of special purpose equipment called for.

The hot gas process

THE welding of polythene and PVC follows the general pattern of gas welding processes. There are, however, important differences, the welding temperatures are comparatively low, and the materials are never exposed directly to a flame or reduced to a molten state.

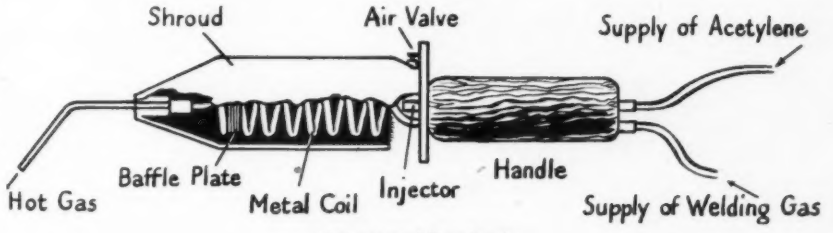
A hot gas process is employed for welding these plastics. Nitrogen is used as the welding gas for polythene and compressed air for PVC. A filler rod is required and this is of the same material as the parent plastic. This filler rod is obtainable as a wire or string $\frac{1}{8}$ in. in diameter, the polythene being supplied normally in coils and the PVC in rods.

A welding torch of the type illustrated is commonly employed for the process. The welding gas is supplied under pressure to the torch, where it is conducted through a metal coil and subsequently discharged through the welding nozzle. As it passes through the coil the gas is heated by an acetylene flame, which burns in air at atmospheric pressure. The combustion air is admitted through a special valve. Its flow, together with that of the acetylene, is adjusted to heat the welding gas to the desired working temperature.

Welding torches in which the gas is heated electrically are also obtainable.

Before welding the plastics must be carefully prepared. The sections to be joined must be clean and oil free, and the adjacent edges chamfered to form a V having an included angle of 60°. It is advisable to leave a root face of approximately $\frac{1}{16}$ in. on the butting edges.

The welding of sheets and plates is carried out in the following way. The sheets to be welded are prepared and clamped in position with their edges butting. Where possible, the sheets should be also clamped to a flat glass or non-ferrous metal plate, which serves to stiffen the sections during the process and control the weld penetration.



Hot gas welding torch.

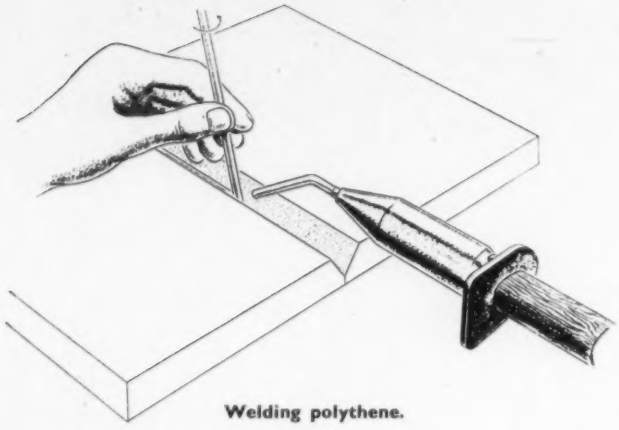
Polythene

The manual techniques used in welding polythene and PVC differ slightly, although in principle they are similar. For polythene a bottled supply of nitrogen is used. The gas is heated in the torch so that it discharges from the nozzle at 570°F. The operator holds the torch in his right hand, the filler rod in his left, and welds in a 'rightwards' direction. At the beginning of the run the tip of the polythene filler rod is pressed firmly into the welding groove. The hot nitrogen is directed at the point of contact between the filler rod and parent material until both become plastic and fuse. As the run continues, the filler rod is inclined sharply away from the torch and fed under steady pressure, so that it is simultaneously laid down into the welding V and fused. As the filler rod is directed into the groove it is turned slowly between finger and thumb to ensure that it is evenly heated and fuses completely with the parent material. The torch is advanced steadily along the run, its nozzle being kept about $\frac{1}{4}$ in. away from the point of contact of the filler rod. At the end of the run, the filler rod is pulled and broken clear of the weld. Care must be taken to prevent overheating and the tip of the filler rod must not be reduced to a molten state. Descaling between welding runs is unnecessary.

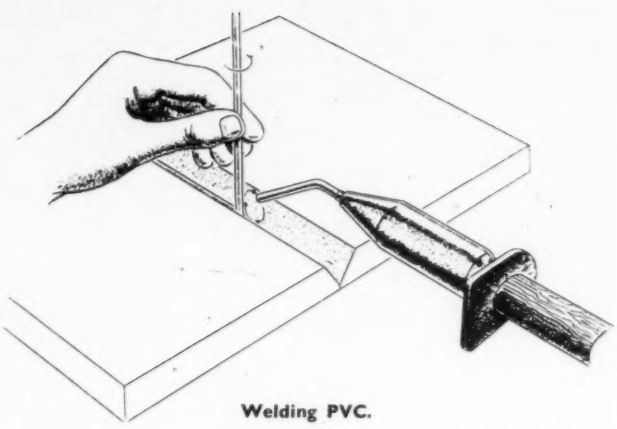
PVC

A mains supply of compressed air regulated to a pressure of about 5 p.s.i.a. is commonly used when welding PVC; the technique employed varies from that used with polythene, as the latter is less rigid. The sheets to be butt welded are prepared and clamped in position as described earlier. The filler rod is held vertically and pressed firmly into the welding V. The nozzle of the welding torch is held $\frac{1}{4}$ in. away from the point of contact of the filler rod, and the jet of hot air is directed along the groove towards the rod, fusing the latter and the butting edges of the sheets. The filler rod is held perpendicular to the sheets throughout the run and pressed firmly into the groove, so that it bows slightly. It is also turned to ensure even heating, as in the polythene welding technique. The torch is moved with a weaving action, up the rod

(Above) **Welding a bend in a polythene tube.**



Welding polythene.



Welding PVC.

for $\frac{1}{4}$ in., down into and back along the V again towards the tip of the filler rod. The cycle is completed several times per second and this movement serves to preheat the filler rod and future welding zone. There is always a slight browning of the contact surface, but care must be taken to avoid overheating. If there is a slight charring of the rod or parent material, the burnt portions should be scraped away before continuing the run. At the end of the run the filler rod is broken clear of the weld.

The number of runs laid down is, of course, governed by the thickness of the material, three passes being used with $\frac{1}{8}$ in., six with $\frac{1}{4}$ in. and 10 with $\frac{3}{8}$ in. thick material. The runs of filler rod are built up on each other pyramid fashion. If the back of the work is accessible a sealing run on the underside should be made. Alternatively, heavier plates can be prepared with a 'double V' and welded both sides.

The filler rod should be neither stretched nor compressed as it is fed into the welding groove. The length of run will equal the length of filler rod used, if the weld is stress free.

The methods employed for fillet welding differ little from the butt welding techniques. The sections to be welded are cleaned and clamped in position. The filler rod is fed under steady hand pressure into the V formed between the sheets to be welded and fused to the parent material by the hot gas. The welding runs are built up on each other in a pyramid fashion to give a fillet of the required depth. When forming corner welds between sheets, a sealing run inside should be laid down if there is access.

Tube fabrication

The basic procedures for butt and fillet welding polythene and PVC sheets can be readily applied to the welding of tubes, which are now available in sizes up to 12-in. bore. The complete range of welded joints called for in tube fabrication can be carried out in the plastic materials.

The butt-welded joint is frequently used. Small-bore pipes can be butt-welded without the use of either welding torch or filler rod. The following very simple method is used. The ends of the tubes to be welded are cut square to the pipe axis and the inside edges of the tube wall are chamfered at 30°, leaving a land on the outer edges. The ends of the tubes are cleaned and then held close to an electric fire or hot steel plate until they start to melt. The heated ends of the tubes are pressed firmly together, twisted slightly to break the oxide film and held under steady pressure until they cool. It is advisable to use a jig or clamp to line the ends of the tubes up accurately. When possible, the pipes should be rolled on a flat plate as they are cooling to form a neat weld penetration. In no circumstances should the heated tubes be quenched in water.

When butt welding pipes of heavier wall thickness or larger bore, it is necessary to employ the hot gas process. Again it is necessary to prepare the ends of the tubes to be joined. A normal 60° V preparation is used and the tubes are clamped in position, allowing no gap between the butting ends. The filler rod is laid down into the welding groove and fused with the parent material by the hot gas. The polythene or PVC filler rods are fed in, using similar techniques to those described earlier for sheet welding. The number of passes is again governed by the wall thickness of the tube, the filler rod being broken clear of the weld at the end of each run and the two ends fused together. The runs of welding are built up pyramid fashion to give a good welding reinforcement.

Sleeved joints are called for on occasions and these are made in the following way: The sleeve, which should be an interference fit on the pipes when cold, is heated by immersing in hot water until it expands sufficiently to allow the ends of the pipes to be joined to be positioned within it. The sleeve is then allowed to cool and shrink on to the pipes. Fillet welds are then laid down at each end of the sleeve to seal the joint.

When a connection to a valve or vessel has to be made, flanged pipe joints can be used. Flanges cut from plates of the same material as the tube are machined and drilled to match the mating flanges. The flange is positioned on the tube, a heavy fillet weld of several runs is laid down at the back of it in addition to a sealing run inside. When flanged polythene pipework is fitted it is customary to reinforce the plastic flanges with metal backing rings. Backing flanges, however, are not required with PVC, the material itself being sufficiently strong to withstand the stresses imposed. Where plastic flanges are used joint rings or gaskets can generally be dispensed with, the flanges being sufficiently resilient to form a leakproof joint when securely bolted in position.

Branch joints and T pieces can be fabricated from polythene and PVC tubes. The saddle of the joint is developed or marked, using a template and cut-out. The branch pipe is shaped to fit the saddle formed in the main and the edges of the pipe to be welded together are carefully chamfered. The pipes are then held or clamped in position and filler rod is fed into the welding groove and fused with the parent material by the hot welding gas.

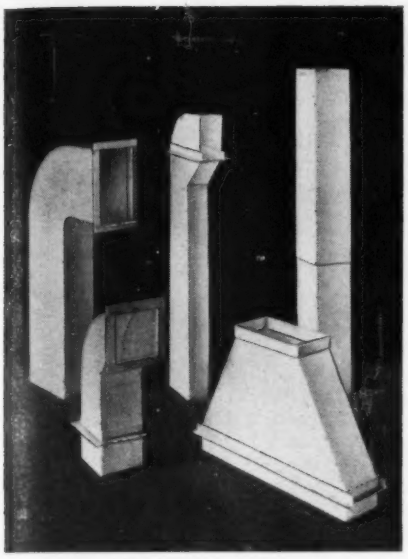
Extruded polythene and PVC tubes up to $1\frac{1}{2}$ in. diameter bores can be bent to any required angle with a spring after they have been softened in hot water. However, with larger bore and heavier wall tubes, bends must be segmented or 'cut and shut.' The latter form of construction is recommended. The bend is developed, gussets are cut out and the bend closed or 'shut.' The butting edges are chamfered and welded together.

Standard pipe reducers are obtainable as mouldings. However, the plastic tubes can be swaged by cutting out gussets, closing in the pipe and welding.

When fabricating polythene and PVC tubes the work is generally assembled so that welding can be carried out downhand. But there is little additional difficulty in welding the tubes in position, as there is no molten pool of material to control in the process.

Applications in industry

As a result of the development work carried out during the last few years, it is now possible for the engineer to fabricate



Examples of fabricated polythene ductwork.

polythene and PVC with, if anything, greater facility than most metals.

In common with other corrosion-resisting materials of comparative high cost, polythene and PVC sheets are frequently used to line tanks and vats. The sheets may be butted or lap-jointed or cover straps may be employed. It is advisable to cement the sheets or secure them by mechanical means to the tank walls. All joints between sheets should be seal-welded. Stirrers and rotors which have to be immersed in corrosive fluids for long periods are frequently fabricated in polythene or PVC; components manufactured in steel and covered by a protective plastic sheath are also commonly used.

Polythene and PVC buckets, containers, funnels and flasks, fabricated from moulded sections and tubes, are included in the equipment of most modern laboratories.

Ventilation and extract ductwork carrying corrosive gases is often constructed from polythene or PVC sheets welded together. The plastic light gauge sheets can be formed up into either rectangular or circular section ducts, the trunking being flanged and stiffened with external metal stiffeners. Ventilation hoods for fume cupboards are frequently made in polythene.

Although tubes are normally obtained extruded, when small quantities of non-standard bore tubes are required, these can be fabricated from sheet. The sheets are immersed in hot water and softened, cut to size, their edges prepared for welding, reheated until they become pliable and formed into cylinders. The longitudinal seams of the tubes are welded when the sheets have cooled and become permanently set. As an alternative, the sheets can be softened, formed into a tube of triangular section and welded longitudinally. The triangular tube is then re-softened and formed into circular section by driving a mandril through it. *(To foot column 2)*

Distortion in Welded Vessels

FOR his presidential address to the Institute of Welding in London recently, the incoming president, Mr. A. Robert Jenkins, J.P., A.M.I.Mech.E., chose the subject of distortion in welded work. He said that comparatively little had been written about it, probably because so many variables affecting distortion were encountered in shop practice and technique; these variables gave rise to very mixed results which made it extremely difficult to arrive at a common basis on which to fix reliable rules. Mr. Jenkins mentioned the following 10 variables, which, he said, were among those which had to be considered in relation to this problem:

(1) Type of material and thickness.
(2) Method of preparation of plate edges.
(3) Design.
(4) Amount of restraint on plates during welding.
(5) Accuracy of set-up.
(6) Type of electrode.
(7) Size of electrode and current.
(8) Rate of deposit.
(9) Number of runs.
(10) Manual or automatic welding.

Distortion was produced by shrinkage, the degree of which could be affected by all the variables mentioned. Shrinkage was the residual contraction in volume of the metal after cooling, and distortion ensued if the temperature distribution had not been uniform, as was the case with arc welding.

Mr. Jenkins said he proposed to give the results of shop tests designed to show the extent of transverse and longitudinal shrinkage, and then to discuss practical methods of preventing and reducing distortion, of counteracting it when it had occurred, and of controlling it by staying and strutting; finally he would describe how welded vessels, which, through accidents, had been distorted almost beyond repair, were made usable again by special treatment.

The results were then shown of a number of tests for distortion carried out by the manual arc welding with electrodes of various gauges on a ½-in. thick plate with V-preparation; these tests showed that a greater degree of *longitudinal* distortion occurred when larger electrodes and higher currents were used, even when the plate was welded from the ends to the centre, a practice which is supposed to reduce distortion. On the other hand, according to examples cited by Mr. Jenkins, a greater degree of *transverse* distortion was to be expected where small electrodes were used with a greater number of runs. As transverse distortion was the more troublesome, it was the practice to make the weld with the minimum number of runs and at the maximum speed. Mr. Jenkins said that the correctness of this method was confirmed by the results of similar tests carried out on a 1½-in. thick plate welded manually and by the submerged arc process.

The president mentioned four ways of minimising distortion. The first was to make initial allowances, to be added to the drawing dimensions, during the preparation of plates, and he suggested some figures for this which were based on practical experience in the construction of tanks and cylinders. Another method was to use a sequence of welding which balanced the contractional stresses, while a third was to ensure that plates were carefully prepared for welding, so that large gaps were not left in the joints. Fourthly, regarding transverse distortion, Mr. Jenkins again stressed the advantages of using large-gauge electrodes and high currents with a consequent reduction of the welding time.

Where distortion had already occurred it could be corrected, as it had been caused, by local heat treatment, for which an oxy-acetylene flame was used. Various examples were shown of this method, which must, however, be very carefully applied if it is not to result in fresh distortion.

Restricting the movement of the plate during welding was one method of preventing distortion and Mr. Jenkins illustrated how this could be carried out where, for example, flanges were to be welded on to two identical objects. It was first necessary to tack-weld the flanges into position, after which the two objects were clamped back to back with packing between them. Welding was then completed and the clamps broken after cooling. Slides were shown illustrating the various ways in which this principle could be applied to prevent the movement of the plate during welding and said that in every case where it was used the edges after welding had remained perfectly straight. Other methods illustrated were the use of stays and struts to maintain shape during welding and the pre-setting of parts before welding, the former being particularly valuable in the case of welded tanks.

In conclusion, the president showed slides of a number of welded vessels which had undergone accidents in service and described the methods by which the resulting distortion had been corrected.

Welded polythene and PVC pipelines now hold an established position in modern chemical plant construction, where their uses range from cold plumbing to low-temperature process and effluent lines. In a laboratory block recently constructed the entire waste system was fabricated from rigid PVC tubes.

The ease with which these plastics can be worked tends to reduce the cost of equipment manufactured in them. This factor, combined with the long life that can be expected with polythene and PVC by virtue of their great resistance to corrosion, frequently offsets the higher raw material cost and makes the equipment an economic proposition.

The two photographs are the copyright of Matthew Hall & Co. Ltd.

SIZE REDUCTION

Grinding theory; Operational principles; New constructional materials; Crushers, disintegrators, pulverisers, ball mills and jet pulverisers; Special applications of size reduction

By R. V. Riley, Ph.D., B.Sc., F.I.M.

Theory

DURING the period under review, F. C. Bond[1] has brought forward his 'third' theory of comminution which promises to remove some of the uncertainties from the current relationships and to permit more accurate calculation of such factors as crusher size, circulating load, proper ball and rod sizes and mill speeds.

If W = work in kwh./short ton to reduce from a feed with 80% passing a diameter F microns to a product with 80% passing P microns, then:

$$Wi = W\left(\frac{\sqrt{F}}{\sqrt{F}-\sqrt{P}}\right)\sqrt{\frac{P}{100}}$$

where Wi = 'work index' or kwh./ton required to reduce from a theoretical infinite size to 80% passing 100 microns.

The size in microns at which 80% passes was selected, rather than that at which 100% passes, as the criterion of feed and product sizes, since this was found in practice to be quite definite and reproducible.

The work index (Wi) may be found experimentally from laboratory crushing and grinding tests or from commercial mill operations. For a jaw or gyratory crusher:

$$Wi = 2.59\ C/S$$

where C = impact crushing resistance in ft.lb./in. of thickness required to break and S = specific gravity.

The kwh./ton can then be calculated from the original equation, rewritten and transposed:

$$W = Wi\left(\frac{\sqrt{F}-\sqrt{P}}{\sqrt{F}}\right)\sqrt{\frac{100}{P}}$$

While the charges for power in the operation of crushing and grinding are usually high, since the process of comminution is by no means efficient, there are other costs equally important. The value of metal worn away, lost by corrosion and thrown away as worn parts in crushing and grinding often approaches or exceeds the power cost. The wear rate is usually expressed as pounds per ton of product, but Bond stated that the index in terms of kwh. input per lb. of metal lost furnishes a more useful indication. Rough values were quoted as in Table 1.

[*Photo: Wilkinson Rubber Linatex Ltd.*

The 'Linatex' Model C.20 ball mill. It has a grinding cylinder 2 ft. long × 2 ft. diameter (internal dimensions). The drive to the cylinder is made via rubber-faced rollers powered by the self-contained unit comprising an electric motor and reduction gear. The patented design of the cylinder gives it virtually a solid rubber wall, overcoming the difficulties associated with separate liners for mills. The 'Linatex' rubber used is claimed to be highly resistant to abrasion and nowhere in the cylinder is the material being ground exposed to metallic contamination. A peripheral hand hole and completely removable end is fitted on this model, which greatly facilitates emptying and cleaning where batches of different materials are being ground.

Table 1

Type of operation	*kwh./lb. of metal lost*
Wet grinding:	
Balls and rods	7
Mill linings	30
Dry grinding:	
Balls and rods	35
Mill linings	150
Hammer mills	5—10
Fine crushing	30
Coarse crushing	40

Dry grinding was stated to require 133% as much power as wet grinding. Furthermore, in an air-swept mill the fan may take an additional 50% of the total power input to the mill. Other points dealt with include volume of the grinding charge, pulp dilution, mill diameter and length, ball segregation and circulating loads.

W. F. Carey and C. J. Stairmand[2] also discussed grinding theory. In an attempt to overcome the shortcomings of the Kick and Rittinger hypotheses, they proposed a new method of calculating the energy absorbed in comminution. Their 'associated energy concept' provided a yardstick with which a practical value could be obtained for the grinding efficiency of industrial mills. On a number of installed mills, efficiencies ranging from 6 to 36% were observed. Wet grinding took less power than dry grinding. They distinguished carefully between free crushing and aggregation. In jaw crushing, a reduction ratio of over 4 usually gave rise to aggregation which not only led to lower crushing efficiency but resulted also in more destructive wear of the crusher jaws.

Operational principles

The two papers by Bond and Carey and Stairmand, to which reference has been made, were part of a very important symposium on mineral dressing arranged by the Institution of Mining and Metallurgy, which took place in London on September 23-25, 1952. Two other papers presented at this conference are worthy of note for their contribution to general operational principles. G. J. Brown[3] observed that the basic principle upon which a crusher works is usually one or the other of the following:

'(1) Direct pressure or squeezing between two surfaces until the rock is fractured along lines of weakness.

'(2) Free impact, *i.e.* sharp impact while the rock is freely suspended, causing the rock to shatter, not necessarily only along lines of weakness.'

A number of broad principles, known as a result of experiences with rock crushers, were stated:

'(1) When the rock contains a predominant proportion of material which has a tendency to be cohesive when moist, any form of repeated pressure crusher—such as a jaw or gyratory type—will show a tendency for the fines to pack in the lower part of the crushing zone and retard or prevent free discharge at fine settings.

'(2) If the rock is highly abrasive, the impact types of machine will show

high maintenance cost, owing to rapid wear.

'(3) When the ratio of reduction is more than about 3 to 1 smooth rolls are usually unsuitable.

'(4) When the rock is reasonably granular in structure and does not produce fines which tend to be cohesive, the gyratory or jaw types have found much favour for primary crushing.

'(5) When the rock is not hard but cohesive, slugger rolls, such as are frequently used on iron ores, give satisfactory performance.

'(6) For rock such as medium-hard limestone, large hammer crushers are often used to effect a considerable ratio of reduction in one stage.

'(7) Where large capacity per unit is required, together with a high reduction ratio, then the gyratory type has many advantages; for example, to reduce 400 tons/hr. from 30-in. cube blocks to a product passing 5-in. square would need one 36-in. gyratory crusher with a 200-h.p. motor; but to fulfil these conditions with jaw-type crushers would need two 36-in. by 48-in. machines, each with a 150-h.p. motor. In addition, some form of feed control would be required, whereas these would not be necessary in the case of the gyratory machine.

'(8) However, if the capacity required were, say, 175 tons/hr. with other conditions the same, then one jaw crusher as above would be able to fulfil the duty.

'It is in the crushing of tonnages of, say, above 500 tons/hr. that the gyratory can be used to its full advantage, and where the jaw crusher is usually less of a competitor.

'Also where the material to be crushed is of a laminated type the gyratory crusher will usually yield a more cubical product even when underfed.

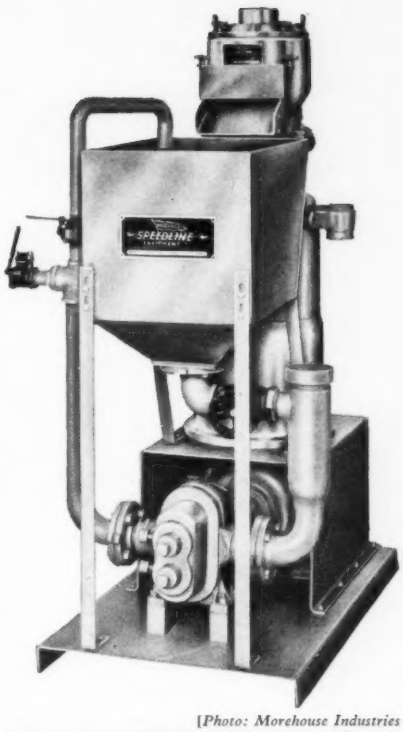
'(9) For secondary reduction the high-speed flared-head gyratory easily leads, except where sticky material precludes its use.

'(10) For capacities below, say, 6 or 8 tons/hr., and a product above, say, $\frac{1}{2}$ in., the single-toggle granulator has much in its favour from the viewpoint of cost, power consumption and maintenance.

'(11) For rock unsuitable for any of the above purposes, smooth rolls with or without suitable scraping and cleaning devices will serve best, within the limits of their ratio of reduction.

'(12) When the material tends to "pack" or is sticky but not abrasive, the "Dixie" type of hammer crusher with moving-band breaker plate has been found suitable for fine crushing.'

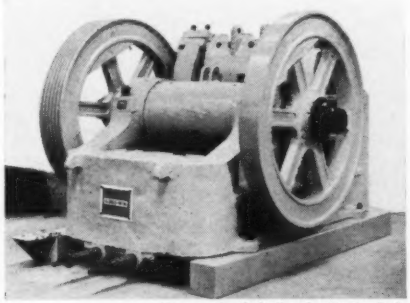
A special study of the rod mill was undertaken by J. F. Myers[4] and this has produced interesting data upon this little-understood form of grinding. The rod mill can be regarded as the modern form of stamp mill. This latter form of mill



[Photo: Morehouse Industries

A 'Speedline' Model B 1405 grease mill with de-aerator. It is designed for the complete milling and de-aeration of a variety of lubricating greases. Power is provided by two open drip proof motors. Operation is most efficient when the mixture to be processed is fed to the mill at a pressure not exceeding 20 p.s.i. Rotor and stator are never in positive contact during the milling operation. The amount of milling action is determined by the clearance between the stones, usually from 1/1,000 to 5/1,000 in. Rates of production as high as 8,000 lb./hr. are claimed. It can be put into operation wherever it can be connected to an electrical circuit and water or steam outlets for cooling or heating purposes.

suffered from the disadvantage that the grist could not be moved and thus aggregation quickly took place with a resultant loss in crushing efficiency. The forces



[Photo: Goodwin Barsby & Co. Ltd.

The 'Good-Win' 36 in. × 20 in. roller-bearing Blake primary jaw crusher. It is of double-toggle design and is made in cast steel. The larger models (42 in. × 32 in.) are used for primary reduction and the smaller for road stone production. The roller bearings reduce the power required and maintenance costs. Both models have water-cooled bearings and automatic lubrication.

which operate in the rod mill are analysed as:

(1) Impact crushing by falling rods.
(2) Impact crushing by lift liners.
(3) Scissoring which causes shearing of some particles.
(4) Crushing by the rolling rods.
(5) Grinding action by lateral and horizontal slip of the rods.

Actual tests made upon the full scale confirmed the importance of all the above factors.

A simple but accurate method of comparing grinding resistance was described by H. L. Podmore.[5] To compare the resistance to grinding of two samples of felspar A and B, the procedure is as follows:

'Determine the specific surface of a sample of partly ground felspar A and also that of the partly ground standard limestone. Mix the two materials in equal proportions by volume and charge into a ball mill. Grind for a suitable period of time and then determine the specific surface of the mixture. Place the mixture in dilute hydrochloric acid to remove the limestone and determine the specific surface of the remaining felspar. From the figures obtained, the increase in surface on the limestone can be compared with that on the felspar under identical conditions of grinding. The experiment is then repeated with felspar B, so enabling its grinding resistance to be compared with that of felspar A. The resistance to grinding of limestone has been arbitrarily fixed at 1. If, therefore, material develops twice as much surface as the limestone under the conditions of the test then its resistance to grinding is 0.5.'

Crushed material is always an agglomeration of differently sized and shaped particles. E. Frenay and R. Colles[6] posed the question: 'Is it possible to predetermine the results of a crushing process?' A laboratory test was proposed which to some extent simulated the behaviour of a works' crusher. B. Beke[7] considered the same problem and demonstrated that the Rosin-Rammler formula was suitable for particles over 2 micron of coal and limestone. T. Tanaka[8] considered similar problems with cement clinker grinding.

Research

Much remains to be discovered about the development of a true theory of size reduction and the rationalisation of operational principles. The Department of Scientific and Industrial Research, in a report of the Committee on Chemical Engineering Research, 1951,[9] include in a classified list of urgent needs for early investigation, the following:

(*a*) The relation between the power consumption and size of crushed product.
(*b*) An investigation into methods of avoiding or overcoming the effects of the contamination of

the products by the materials of construction of the mill.

(*c*) The theory of fracture of solids by thermal shock.

(*d*) Size reduction of natural products, *i.e.* grains and fibres.

(*e*) Fine grinding without temperature rise, especially for cork and wood flour.

Research methods employing radioactive tracers have again featured in comminution investigations. A. M. Gaudin, *et al.*,[10] discussed the use of tracers for ascertaining the size distribution of a finely ground product. 'Radioactive isotopes in Mineral Dressing Research' is the title of an unclassified report published by the Atomic Energy Research Establishment.[11] This report gave specific examples of the use of isotopes and concluded that for grinding research their use will be extended considerably to study pulp density, mill speed, preferential grinding and particularly the effect of circulating load.

A development of statistical analysis was claimed by O. M. Todes and A. Z. Yurovskii[12] for application to ore crushing. H. L. Alling[13] studied in the laboratory the fundamental behaviour of mineral grains under abrasive conditions. The results showed that in a ball mill this form of abrasion, whilst reducing size also gave more rounded particles. The effect of long grinding upon particle size distribution was also considered by B. C. Bradshaw[14] and A. B. Manning.[15] They stated that, during long continued grinding, the distribution of sizes is not static but varies continuously and leads to the Rosin-Rammler law of distribution. Basic laboratory studies of crushing were described by J. W. Axelson.[16]

Research into the meaning of hardness has continued. P. Grodzinski,[17] already well known in this field of investigation, has produced a new definition of the term 'micro indentation hardness.' The definition of micro indentation hardness as either a stress or a displacement is unsatisfactory. In a carefully reasoned article, Grodzinski shows that since the Meyer law:

$$P = a\,d^n$$

(where P = load applied on test in kg.; d = diameter of indentation; and a and n are constants depending upon material tested) is valid for a large number of materials and shapes of indenters, it is suggested that the hardness h can be defined as the load which causes a deformation of unit length or depth, *i.e.*

$$h = P/d^n$$

To determine the magnitude of this expression with any given material at least two hardness tests must be carried out at different loadings. An apparatus is suggested in which load variation can be made continuously. The new hardness has been correlated with the conventional hardness numbers for a number of materials ranging from nylon to boron carbide.

The *Kentron* microhardness tester for mineral identification and quantitative determination of phases in polished sections was described by F. Robertson and W. J. van Meter.[18] This apparatus combines extreme sensitivity in placement upon a prepared surface with highly reproducible hardness determination. The hardness range, in Knoop values, is from 5 to 1,500 and determination may be carried out on grains as small as 10 microns diameter.

In the very important field of research into the action of quartz particles in the production of silicosis, P. B. Dempster and P. D. Ritchie[19] have discovered the existence of a highly soluble surface layer of amorphous silica upon the grains of siliceous dusts. It appears to be closely associated with the classical Beilby layer on polished solids. This vitreous skin is apparently produced by surface flow during grinding. This may serve to elucidate some of the peculiar instances where grinding operations produce dangerous dusts while other similar grinding methods appear quite safe.

New materials for size reduction machinery

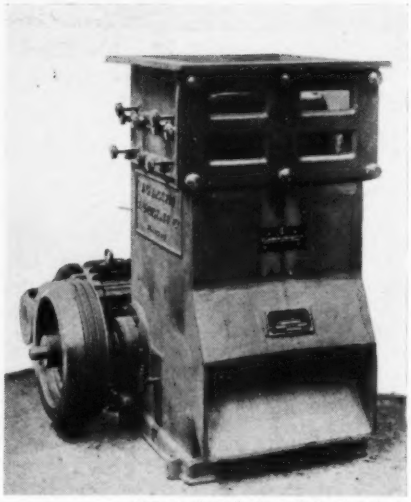
Flint and chert pebbles are now collected from the shingle banks on the Axemouth and Seaton coast of South Devon. A. Bray[20] states that ½-in. diameter pebbles are collected for pigment grinding and those up to 3-in. diameter for general grinding.

D. Weston[21] claims in U.S. patent 2,558,327 a new form for a grinding ball consisting of a short cylinder with hemispherical ends. Burundum grinding balls,[22] twice as heavy as flint pebbles and more than twice as hard, are claimed to improve production rate of a tubular mill by 50%.

Cast basalt has proved to be a very superior wear-resisting lining for parts used in the handling of crushed materials.[23] An average life of 45 weeks was obtained with cast basalt, compared with 6 weeks for chilled cast iron and 2½ weeks for blue brick for the lining of a coke chute.

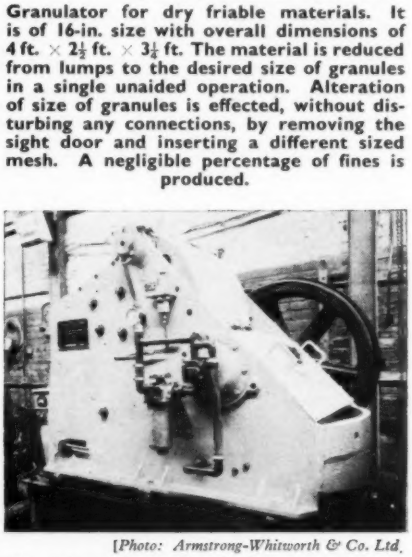
More attention has been given to hard facing of crusher parts. H. S. Avery[24] states that the most appropriate hard-facing materials for crusher parts are martensitic irons, martensitic steels and austenitic steels, which are suitable for positions receiving light, medium and heavy impact respectively. These three types of metals are described in some detail and the tables of data for engineers are very useful. (Tables 2 and 3.)

Hammer mills are regarded as locations of medium impact and generally a martensitic steel is suitable for hard overlays, even though manganese austenitic hammers are usually employed. In jaw crushers, where impact stresses are high, hard alloys usually fracture before they wear out. Manganese-nickel weld deposits give a suitable repair. All these hard-facing metals are readily deposited by electric arc welding methods. Crusher cones[25] of manganese steel, rebuilt and hard-surfaced by electric arc deposits of austenitic steel, are stated to outlast the original castings.



[Photo: J. G. Jackson & Crockatt Ltd.

Granulator for dry friable materials. It is of 16-in. size with overall dimensions of 4 ft. × 2½ ft. × 3½ ft. The material is reduced from lumps to the desired size of granules in a single unaided operation. Alteration of size of granules is effected, without disturbing any connections, by removing the sight door and inserting a different sized mesh. A negligible percentage of fines is produced.



[Photo: Armstrong-Whitworth & Co. Ltd.

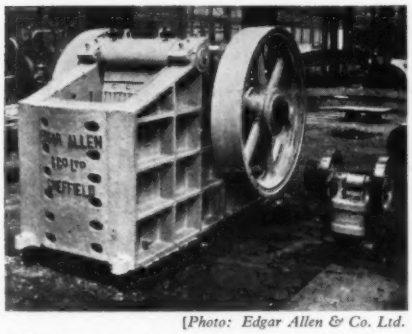
The 'Kue-Ken,' Model 56, jaw crusher (24 in. × 12 in.), one of a range recently introduced in the U.K. by Armstrong-Whitworth who acquired the rights from an American firm. It is built on the principle of crushing by pressure alone. Rubbing is eliminated because the hinge pin is located well above and substantially on the line that passes through the centre of the crushing zone formed by the two jaw plates. The swing jaw, swinging from the hinge pin, must follow the paths of arcs which pass squarely through the centre line of the crushing zone. Wear and power are thus reduced to a minimum. It is claimed that jaw plates last five to ten times longer and capacity is two to five times greater than with older type machines.

Crushers, disintegrators and pulverisers

A short elementary account of mineral crushers is given in a brochure on steel castings.[26] A more detailed description of modern crushers and disintegrators is to

[*Photo: Pascall Engineering Co. Ltd.*

Mill for high-speed reduction of any material that disintegrates under impact. It is bowl-shaped and converges towards the discharge outlet. Inside are two steel discs fitted with concentric rows of toughened steel pins. The lower disc is driven at very high speed, while the top disc remains stationary. The discs accurately mesh with each other without contacting. An automatic shaker feed hopper feeds the mill and the material is impelled by centrifugal force between the discs where reduction takes place by impact against the pins. Intense turbulence is created within the grinding area by the high-speed rotating disc.



[*Photo: Edgar Allen & Co. Ltd.*

This large, 42 in. × 30 in. jaw crusher is made from steel castings sectionalised to facilitate erection. Both stationary and movable jaws are lined with replaceable manganese steel faces. Forced-feed lubrication serves all important bearings. At 180 r.p.m. the crusher discharges 80 to 170 tons of rock/hr. at 4 in. to 8 in. size.

Table 2. A Graded Series of Wear-Resistant Alloys
(listed in order of decreasing abrasion resistance and increasing toughness)

		Properties sensitive to carbon content and structure
Increasing abrasion resistance	1. Tungsten carbide composites	Maximum abrasion resistance Worn surfaces become rough
	2. High-chromium irons	Excellent erosion resistance Oxidation resistance
	3. Martensitic irons	Excellent abrasion resistance High compressive strength
	4. Cobalt base alloys	Oxidation resistance Corrosion resistance Hot strength and creep resistance
	5. Nickel base alloys	Corrosion resistance May have oxidation and creep resistance
	6. Martensitic steels	Good combinations of abrasion and impact resistance Good compressive strength
	7. Pearlitic steels	Inexpensive. Fair abrasion and impact resistance
Increasing toughness.	8. Austenitic steels	Work hardening
	Stainless steels	Corrosion resistance
	Manganese steel	Maximum toughness with fair abrasion resistance. Good metal-to-metal wear resistance under impact

(*Acknowledgments to H. S. Avery*)

Table 3. Hard-Facing Alloy Selection for Impact Service

Material suitable for	*Martensitic irons* Light impact*	*Martensitic steels* Medium impact*	*Austenitic manganese steel Heavy impact*
Yield strength tensile, p.s.i.	60,000—80,000	60,000—80,000	45,000—55,000
Uiltimate tensile strength, p.s.i.	65,000—90,000	60,000—125,000	100,000—150,000
Tensile elongation, %	0.01—0.04	0.01—0.10	30—70
Brinell hardness	500—750	500—750	160—220
Rockwell hardness	C48—C65	C48—C65	Co—C20
Yield strength compressive 0.10% set	150,000—285,000	76,000—175,000	45,000—55,000
Ultimate compressive strength, p.s.i.	265,000—385,000	180,000—385,000	200,000—310,000
Elastic deformation, %	0.8—1.4	0.8—1.5	
Plastic deformation, %	0.2—5.4	1.0—22	30—55
Total deformation, %	1.2—6.5	1.8—23	
Wet sand abrasion factor†	0.30—0.50	0.65—0.80	0.75—0.85
Dry sand erosion factor†	0.04—0.10	0.15—0.55	0.41—1.00

* Untempered, corresponding to the usual status of weld deposits
† Weight loss ratios compared with annealed SAE 1020 steel

(*Acknowledgments to H. S. Avery*)

be found in a sales leaflet of British Jeffrey-Diamond Ltd.[27] A new type of double impeller breaker designed to give a ratio of 20: 1 is claimed by its makers, Fairleede Engineering Ltd.,[28] to represent the first really new method of stone and gravel reduction to be introduced in over 30 years. The material fed into the crusher falls on to the impellers revolving at 1,200 r.p.m. Three bars in each impeller provide the first impact, throwing the fragments on to the steel breaker bars for the second impact. The fragments then hurtle around the breaker, colliding with each other and new material entering the breaker, producing a clean, cubical product with a low percentage of dust. H. Lehmann, J. Parpart and H. G. Buchartowski[29] refer to another efficient type of double impeller breaker for the mineral industry. Jaw crushers for hard minerals[30] and 'multi cut' mills for foodstuffs[31] have been described. H. J. Shelton claims a patent[32] jaw crusher with readily adjustable movable jaw.

Manufacturers of pencils and crayons have applied a form of *Mikro Pulveriser* to the grinding of their clay and graphite and colour sludges in place of ball milling.[33] *Mikro Pulverisers* are available in capacities from 75-25,000 lb./hr.

A. Govoroff[34] describes combined grinding with a drying process for gypsum. The material under treatment is passed through a hammer mill purged by a stream of hot air. The distinction between crushing, grinding and pulverising is described in a general article[35] and a number of hammer mills are treated in more detail. The general principle of size reduction is restated, namely, that it is generally inadvisable to attempt a greater reduction ratio than 5 to 1 in any one type of machine. D. H. Gieskieng[36] deals with the influence of jaw crushers upon the shape of crushed particles. A new guard ring device to prevent the escape of oversize particles from circulatory pulverising mills is claimed by C. Trost in U.S. patent 2,588,945[37] and H. H. Rumpel[38] claims a new type of gyratory crusher.

Ball mills and jet pulverisers

J. G. Campbell,[39] in British patent 665,398, has claimed a method of grinding whereby a more desired distribution of particle size may be obtained. The invention describes a series of ball mills connected together axially by sections of a gradually expanding conical tube that rotates together with the ball mills. This produces presumably a series of interdependent grinding stages.

For large ball mills in which the bigger balls deliver heavy impact shocks, manganese austenitic steel liners are usually recommended.[40] It is noticeable that in American ore-dressing plants the tendency to run ball and tube mills at lower speeds has continued.[41] This is generally considered to improve the efficiency and reduce lining wear. To obtain the output, of course, larger mill units are necessary.

In laboratory grinding jar mills a new development is to provide an adjustable

idler roller, and in this way one unit can be used for a variety of jar sizes.[42] C. C. Dell[43] discusses the technique of release analysis as applied to the ball milling of copper ores. The method consists in working the mill to give an ore particle size which upon subsequent flotation gives the best recovery of copper-rich ore. This technique cuts out unnecessary over-grinding and indicates when re-grinding of tailings is required.

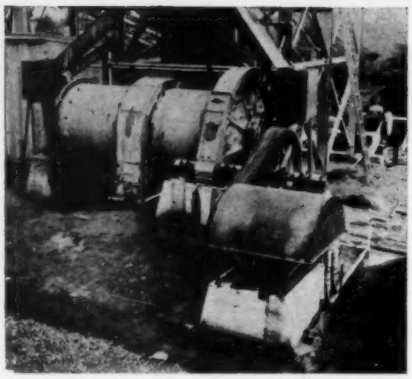
There has been much less attention given in the literature to fluid energy mills. Only one paper is recorded here[44] which gives a general account of the *Microniser* fluid energy jet pulveriser which grinds to 2 microns at a collector efficiency of 85%.

Specialised applications of size reduction

V. H. Stott,[45] in a review of methods of preparing alumina ware refractories, describes the grinding methods suitable for the preparation of the alumina slip. Ball mills are generally used for grinding alumina, but *Micronisers* have also been employed either alone or in combination with ball milling. Wet and dry milling appears equally suitable. The grinding of ceramic materials is also discussed in another article[46] in which details of recommended procedures are given for the preparation of fine powders from glass, quartz, porcelain and synthetic sapphire. J. Lomas[47] discusses the fine grinding of felspar in a typical mill comprising three silex-lined mills with flint pebbles running at 27 to 28 r.p.m. The first tube mill unit has an 8 ft. by 4 ft. mill which discharges to an air separator or a vibratory screen depending upon the grade required. It is claimed that the plant capacity is increased by 8% when a tube mill is employed in this first stage.

Pan grinding is still the usual method of grinding charred bone for the manufacture of bone china clay bodies.[48] The material is relatively soft and the pan lining lasts ten years. The rate of grinding is checked by test sieves and each batch takes 8 to 24 hr. to arrive at condition. A few manufacturers are now adopting cylinder grinding for this purpose. R. M. Berthier[49] discusses eccentrically balanced vibrators for feeding difficult powders to and from grinding mills.

E. J. Perry[50] discusses the operation of a gold-producing company and deals with the crushing and ball milling of ore. A similar description of the crushing and grinding of gold ore is given by O. A. E. Jackson.[51] Treatment is effected in three main sections—coarse crushing, fine grinding and gold extraction. After coarse crushing in jaw crushers and cone crushers, pebble mills are used for fine grinding and the trend is to grind until more than 85% of the product passes a 200-mesh sieve. The increasing cost of iron and steel is making the pebble process more and more desirable. The value of centralised research in planning a mineral milling programme is



[*Photo: Pegson Ltd.*

Fine grinding has been studied extensively by the Mine & Smelter Co., U.S.A., and as a result of this research, three types of rod mills have been produced which are now being made in the U.K. The Marcy principle of grinding—'rapid discharge of mill content is necessary for high efficiency'—is incorporated in all these rod and ball mills. A rapid change of mill content can only be secured by using a low pulp level type of mill. The quick discharge of finished material results in a maximum of useful grinding in reducing oversize particles and a minimum of useless grinding in further reducing material which is already fine enough for the finished product. The photograph shows the Marcy centre peripheral discharge rod mill with a capacity of 100 tons/hr. The range covers from 3 to 200 tons/hr.

stressed by P. G. Kihlstedt.[52] P. J. Dunlop[53] describes how the dust problem in crushing gold ores has been tackled at Consolidated Gold Mines Ltd., Canada.

Dust resulting from size reduction operations is a serious menace to the health of workers and for this reason most works have tackled this problem in recent years. A pneumatic conveyor system, motivated by the Fuller-Kinyon pump,[54] conveys powdered materials such as fuller's earth, clays, soda ash, powdered aspirin, gypsum, carbon black, starches, etc., over distances of 50 to 1,000 ft. The system is totally enclosed and thus limits the dust hazard when used in conjunction with grinding systems. The danger of crushing ferro-silicon is avoided by grinding wet.[55] The ground material is separated from the liquid medium by press filters. Sulphur, whilst presenting little difficulty from the point of view of ease of breakdown, is troublesome owing to its inflammable nature and a more than ordinary likelihood of explosion. Totally enclosed hammer mills or pinned disc mills have been used for some time, but the ring roll mill working in conjunction with a classifier is now finding favour.[56]

In a paper upon graphite, J. Lomas[57] gives data on grinding of this material in disc crushers and ball mills. A new colloid mill is claimed by F. J. E. China.[58]

Finally, E. C. Ellwood and W. A. Weddle[59] have described a novel method of producing copper powder cheaply. Scrap copper wire is oxidised at elevated temperatures, the oxide ball milled to a powder, 83% less than 200 mesh, and this is finally reduced to copper powder by heating in an atmosphere of hydrogen.

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(*Concluded on page* 28)

Tall Oil in Flotation Processes

TALL oil, both crude and refined, have been used as reagents in flotation processes for purifying minerals ever since tall oil became available in commercial quantities. Tall oil became important in the flotation of phosphate rock about 20 years ago and thereafter its use was extended to other minerals such as manganese ores and fluorspar.

The flotation of minerals as a means for their purification is becoming increasingly important with the depletion of high-grade sources. Thus, in the future, tall oil may be expected to be used more and more in the extension of flotation operations to low-grade iron ores. In addition, the principles and techniques developed for the minerals industry are being taken up by other industries having the problem of low cost, large-scale separations or classifications. Here, too, tall oil should prove to be an effective, economical reagent.

Flotation principle

The main principle of the flotation process is quite simple, but its applications involve numerous complexities and few of these are clearly understood, despite many scientific investigations. Publications and patents dealing with flotation and its related art run into the thousands; patents referring to various applications for tall oil in flotation processes alone exceed 50 and, judging from their rate of appearance, there will soon be many more.

Flotation means what the name implies —the floating of things that normally sink in water. This is done by making air bubbles stick to a substance so that it becomes buoyant, just as a would-be swimmer gains support from the air in water wings. The commercial importance of flotation processes comes from the fact that substances like tall oil cause air bubbles to stick preferentially to particles of some materials and not to others. The result is thus a separation, with some kinds of particles floating, others sinking. The substances which, like tall oil, cause air bubbles to adhere are termed collectors.

Since air bubbles are generally small, the substance to be floated must be in correspondingly small particles to become buoyant. Mineral particles much larger than 300 microns are not usually recovered by froth flotation. On the other hand, when particles are too fine they so outnumber the air bubbles that flotation is not effective. In ordinary flotation cells, particles much smaller than 20 microns are not readily floated. However, by reducing the size and increasing the number of air bubbles, particles as small as 2 microns can be effectively floated.

Collectors

In general, air bubbles stick to the surfaces of particles suspended in water only when the surfaces are water-repellent. Most minerals are not naturally water-repellent, but hundreds of chemicals are available that can be made to react with mineral surfaces to yield compounds of the desired surface activity. The two principal types of collectors are fatty acids and xanthates. The latter form insoluble compounds with heavy metals like lead, but not with alkaline earth metals like calcium. Fatty acid compounds of both heavy metal and alkaline earth metals are insoluble. When such insoluble compounds coat a mineral, its surface becomes more water-repellent.

Other types of collectors based on amines and other cationic surface-active agents are also used. For example, sand particles can be floated in the presence of amines. As a collector, tall oil resembles the action of fatty acids like oleic acid, and the effectiveness of tall oil is generally believed to be due to the fatty acids in tall oil. The lower cost of tall oil favours its use over more expensive fatty acids sources. Cationic compounds of tall oil such as tall oil amines are still in the experimental stage.

Modifiers

The choice of a collector thus depends, basically, on the minerals to be separated. The action of collectors can also be repressed or enhanced by the addition of various chemicals, depressants, activators and other modifying agents, which serve to control the *p*H or other ionic concentrations, to act as coagulants or as dispersants. In addition, much depends on the quality of the available water, the impurities in the ore, its particle size range and many less tangible factors.

Frothers

In practice, flotation is not effected merely by attaching air bubbles to the desired ore grains. When such particles balloon to the surface the bubbles must remain stable long enough for their attached particles to be raked away. Stable bubbles also allow time for any undesired particles, lifted by turbulence or occlusion, to settle out. This bubble stabilising action can be improved by the addition of reagents termed frothers. Pine oil and cresylic acid are the most commonly used. Frothers are generally not required with fatty acids, the acids themselves having a frothing effect. Tall oil often develops more than enough froth, but this is readily repressed to the desired degree by the addition of fuel oil.

Flotation plants

The flotation process is used mostly in the separation of minerals, and equipment for such operations has become more or less standardised. The recent extension of flotation to other materials has also led to the design of special flotation cells and other equipment.

In the usual ore operation, for the flotation process to be efficient, the ore must be ground sufficiently fine to 'unlock' the desired mineral. This requires that nearly all the mineral be reduced to grains or crystals from which all undesired substances have broken away. The unlocked ore is then processed in flotation cells. These are tanks in which a stream of the unlocked ore is partially suspended in water in the presence of the flotation reagents. A steady stream of fine air bubbles is also dispersed in the slurry. The desired mineral floats to the top as a froth which is raked off into a collecting trough. The rejected portion, sinking, is withdrawn at the bottom.

This operation may be repeated in a sequence of cells as often as is deemed economical. The performance from cell to cell may also be changed considerably so that not only may the efficiency of separation be varied but, by the proper choice of reagents, the mineral that floats in one cell may be caused to sink in another. The most desirable and economical conditions for cell operations depend on so many variable factors that continued successful operation requires a large store of experience.

Cells are now available for the flotation of fine particles in the 2 to 10 micron range. One such injects air into a pulp suspension under pressure. When the pressure is released the dissolved air forms much finer bubbles than are available with air injected mechanically as in the typical ore flotation cell.

Phosphate rock flotation

Thousands of tons of tall oil are used every year in the flotation of phosphate rock. Of about 9 million tons of phosphate rock mined annually in the United States about two-thirds comes from Florida. Over half of the rest comes from Tennessee.

The great bulk of the Florida and Tennessee deposits are scooped out of pits; the phosphate matrix is usually in the form of pebbles and fines embedded in clay and sand. Brought to the surface, the matrix is disintegrated with high-pressure water and screened. The pieces down to $\frac{1}{16}$ in.—washer rock—are separated out. The fines which, depending on the mine, may be anywhere from 15 to 85% of the phosphate, are washed free of clay and colloidal phosphate. The resulting mixture of sand and phosphate grains is then classified. The particles from $\frac{1}{16}$ in. to about 48 mesh are too large for flotation and so are processed in agglomeration plants. The finer material, up to 150 or even 200 mesh, goes to the flotation plant.

Tall oil, in competition with other fatty acids, is used in both the agglomeration and the flotation plants.

In the agglomeration plant, the coarser fraction of phosphate is oiled with a mix-

ture of tall oil or other fatty acids, caustic soda and fuel oil. The oil displaces the water from the phosphate surfaces but not from the sand surfaces. The oily surfaces adhere, so that the oiled phosphate particles agglomerate in water. When such a product is screened or classified in water the fine sand grains separate from the agglomerated phosphate.

In the flotation plant the finer fraction of the phosphate, suspended in water, is mixed with the reagents and then enters the flotation cells. The phosphate grains, coated with oil, adhere to air bubbles and are collected as a froth. The uncoated sand settles and is discharged. The amounts of the various reagents vary considerably from plant to plant and must be kept closely adjusted to changes in the quality of the feed, but a typical use would be: tall oil 0.5 lb., caustic soda 0.3 lb., fuel oil 1.3 lb., per ton of mineral feed. A recovery of better than 90% of the phosphate is to be expected.

The flotation operation can also be conducted in two stages. The process is said to be less expensive to operate, though it costs a little more for reagents. The first stage uses the same reagents, tall oil, caustic soda and fuel oil, in the same amounts. The feed is heavier, that is, it is put through more rapidly. The result is a somewhat higher recovery of phosphate containing considerable sand.

In the next stage the occluded sand is floated and the phosphate is made to sink. This is done by acidulating the pulp slightly with sulphuric acid to remove the fatty acid coating from the phosphate. The resulting slimes are washed out and the de-oiled pulp is then treated with the amines of higher fatty acids, or of rosin or tall oil. A little caustic soda is also used, together with a frothing agent such as pine oil. The result is that the sand, attached to air bubbles, is frothed off, the phosphate being drawn off the bottom.

Manganese ore flotation

Tall oil and fatty acids are also used in concentrating this ore, although not so universally as in the case of phosphate rock. In many of the American ores the manganese mineral particles are so small that to unlock them by grinding would make the particle size too small for efficient flotation. The Bureau of Mines conducts numerous tests on domestic manganese ore supplies. Cuban ores and the very large deposits of rhodochrosite ores near Butte, Montana, are successfully concentrated by flotation using tall oil or fatty acids.

The Montana ores, containing about 21% manganese, are ground to pass 65 mesh. Zinc sulphide is first floated off using xanthate, pine oil and other chemicals. The rhodochrosite, a manganese carbonate, is then floated with tall oil or fatty acids and caustic soda. This yields the mineral assaying about 40% manganese. When this is roasted the resulting manganese oxide assays about 60% manganese.

Iron ore flotation

The depletion of high-grade iron ores from domestic sources has become serious enough to make lower-grade ore operations economical. Lower-grade ores often require enrichment or beneficiation before smelting. Developments are maturing for the utilisation of about 15 million tons annually of magnetic taconite from the Mesabi range in Minnesota. Plans for non-magnetic taconites have not yet advanced so far.

The magnetic taconites are beneficiated by a magnetic separation process after grinding the ore very fine. The separated, finely divided iron mineral is pelletised, an operation for which tall oil appears to be an effective binder. The pelletised mineral after sintering must be strong enough to withstand crushing when loaded into blast furnaces.

Flotation processes are also being developed and tall oil with its long record of steady availability is favoured by many investigators as the best source of domestic fatty acids.

Other minerals

Many other minerals are being floated with tall oil and other fatty acids. Most of the metallic oxide minerals respond to this type of collector. The sulphide minerals usually require xanthates, the silicates, amines.

A list of minerals where tall oil or fatty acids are effective would include:

apatite	magnesite
barite	magnetite
bauxite	manganite
beryllium ores	manganese ores
calcite	muscovite
celestite	phosphate ores
cement rock	pyrolusite
chromite	psilomelane
cryolite	rhodochrosite
copper ores (oxidised)	rutile
corundum	scheelite
dolomite	siderite
fluorite	sillimanite
fluorspar	spodumene
hematite	taconite
ilmenite	tin ores
iron ores	tungsten ores
kyanite	vanadium ores
limestone	zinc ores
zircon ores	

Other material

The principle of flotation has been successfully applied to such diverse operations as the recovery of fibre and pigments from paper mill waste white water, the reclamation of oils from waste water, recovery of fossil resins from bituminous coals, the removal of ergot from rye grains, the cleaning of wheat and even the cleaning of shelled peas.

Flotation and with it, tall oil, as a very low cost reagent, has many possibilities in the processing of industrial wastes for the recovery of many valuable constituents heretofore considered too dispersed or too dilute to be worth while.

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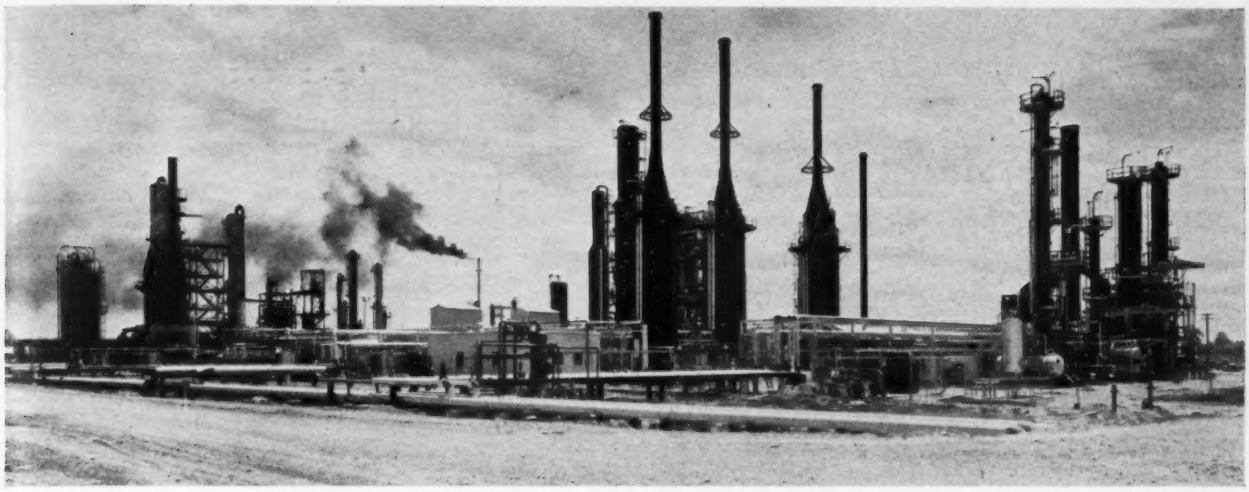
Catalytic cracking. A decade of historical engineering developments in fluid catalytic cracking from the first units at Baton Rouge to the most modern *Orthoflow* converters are discussed in the *Kelloggram* published by the M. W. Kellogg Co. The publication points out how modifications of the prototype design have led to marked decreases in the sizes of the various vessels, the elimination of others and important savings in the initial cost of units. These changes in the design, says Kellogg, are due not only to increased efficiency of the process, but also to specific mechanical engineering improvements. In addition to discussing fluid catalytic cracking in general, the issue also describes the new *Orthoflow* converter, a Kellogg development. With seven of these either now in operation or currently under construction in the United States, Canada and Europe, indications are that this new, economical design is fulfilling a need for both large and small refiners, states Kellogg. Units now operating range from 2,500 to over 8,000 barrels/day capacity, while those currently under construction include one with a fresh feed capacity of 28,000 b.p.d. and a reactor throughput of 45,000 b.p.d.

Beyond the actual single-vessel design feature of the *Orthoflow*, one of the most important improvements lies in the straight-line flow of the catalyst transportation system. Even the most carefully designed fluid crackers of the more familiar side-by-side type had a maintenance problem at the bends in the catalyst carrier lines. Straight-line transmission reduces the erosion that naturally occurs as the fine particles of fluidised catalyst move at high speed through large pipes between the reactor and regenerator of a unit.



Left to right: **Catalytic cracking, crude distillation and catalytic reforming units.**

New Oil Refinery in Ontario

INTEGRATION WITH CHEMICAL AND SYNTHETIC RUBBER PLANTS

By E. A. Smith* and F. J. Maslyk†

A new petroleum refinery for processing annually 5 million barrels of Alberta crude, recently went on stream at Sarnia, Ontario. It is operated by Canadian Oil Companies Ltd., and it cost $23 million. The refinery typifies the modern trend in the oil industry in that it is integrated with a chemical factory and a synthetic rubber plant which utilise as raw materials various liquid and gaseous by-products of refining. The refinery is the most modern in Canada, with the first fluid catalytic cracker and the first catalytic reformer ever to be installed in that country. Here is a detailed description of the processing units and ancillary plants of the refinery.

ITS fiftieth birthday as a refiner was celebrated last year by Canadian Oil Companies Ltd. The firm embarks on its second half-century with a new $23 million refinery at Sarnia, Ontario. The new plant has been in full operation for some time following a unit by unit start-up beginning last spring, and it was officially opened on September 25 last.

Sixteen miles due west from Petrolia, Ontario, where Canadian Oil Companies first started refining operations 50 years ago, and just south of Sarnia, Ontario, in Moore Township on the St. Clair River, the new plant embodying novel techniques has started to pour the first of millions of gallons of motor and aviation gasolines, jet and other fuel oils, synthetic rubber and chemical ingredients into Canada's expanding economy.

The Sarnia project is part of Canadian Oil's $27 million programme of expansion on half of a 400-acre site which less than two years ago was undeveloped farmland. The new refinery borders on the St. Clair River and is designed to handle 20,000 barrels of Redwater crude oil daily. It was built without frills, but sufficient flexibility was provided to permit special products to be made with minimum additional equipment. Large areas were provided for future expansion of the refinery proper and for the addition of petrochemical industries or other allied industries alongside.

Stone and Webster Engineering Corporation handled the design and construction of practically all the general services. They also co-ordinated all design and construction activities of the many sub-contractors. The administration of all contracts was handled by the project managers.

The water supply systems include: (1) water treating, (2) waste disposal facilities and (3) part of the plant protection devices. The three main process unit groups consist of:

(1) The crude distillation unit.

(2) The catalytic cracking, gas concentration and catalytic polymerisation units.

(3) The catalytic platforming unit. (Platforming, coined from the words platinum and reforming, means the use of platinum as the catalyst in the reforming process by which low-octane naphtha is up-graded into top quality gasolines.)

Unique features of the refinery consist of its proximity to the Federally-owned Polymer Corporation, the only synthetic rubber plant in the British Commonwealth, and to Dow Chemical of Canada Ltd., who have rapidly expanded into one of the major chemical industries in Canada; and the collection, processing, distribution and utilisation of the many gases resulting from refining. Very little gas is burned in the refinery, with the exception of hydrogen sulphide, and it is expected that in the not too distant future even this gas will be sold or utilised for the production of sulphur and sulphuric acid.

Methane, ethane and ethylene from the de-ethaniser go in gaseous stream to Dow, who extract the ethylene and ethane from the stream, crack the ethane to ethylene, which is united with the ethylene extracted from the refinery stream. The methane is utilised as fuel gas.

A liquid stream of propane from the catalytic polymerisation unit also goes to Dow, who crack it to ethylene. Propylene, incident to the pyrolysis of ethane and propane, is returned to the refinery to be polymerised along with the propylene incident to the refining operations and which is separated from the overall gas stream at the C_3-C_4 splitter. The poly plant operates almost entirely on the propylene from the refinery and that returned from Dow. Production of poly gasoline is thereby maintained even though the full C_4 stream is sent to the Polymer Corporation, who separate the isobutylene for the production of butyl rubber and the normal butenes for the production of GRS-type rubber. The

*Canadian Oil Companies Ltd.
†Stone & Webster Engineering Corporation.

normal butanes are returned to the refinery for the control of vapour pressure and front end volatility of the several gasolines produced.

Crude distillation unit

There are five separate operations at the crude distillation unit:

(1) Chemical de-salting.
(2) Crude pre-flashing.
(3) Atmospheric distillation.
(4) Vacuum distillation.
(5) Vis-breaking.

The light naphtha from the pre-flashing, stove and diesel oil products from atmospheric distillation are individually treated for removal of undesirable materials and are sent to storage tanks. Heavy naphtha from the atmospheric column goes to the platformer for up-grading to high-quality motor and aviation gasoline products. Some light gas oil and all of the heavy gas oil from the atmospheric and vacuum columns go to the Kellogg *Orthoflow* catalytic cracking unit for conversion to a high-quality motor gasoline.

Heavy vis-broken residual not required by the refinery is blended with cycle-stock from the catalytic cracker and within the crude unit into bunker fuel oil product and delivered to storage tanks to subsequently be shipped via tanker, motor transport and railway tankcars.

The platformer

Much has appeared in literature dealing with the theory and application of platforming and catalytic reforming. In the platformer, because of its multi-stage, self-regenerating reactor system, several reactions can be induced and completed with comparative ease. Naphthene or cyclic hydrocarbons are dehydrogenated to aromatic or ring-type hydrocarbons. Normal or straight-chain paraffin hydrocarbons are isomerised to branched-chain or iso-compounds. Hydrocracking also occurs, so that altogether the components of the finished platformate are very desirable in both motor and aviation gasolines. The platformer at Canadian Oil has three reactors and there are a few innovations which are interesting. In view of the close fractionation accomplished at the crude unit, it is unnecessary to use a pre-fractionator ahead of the platformer. However, in order to remove last traces of moisture and oxygen from the platformer charge, a small stripper was installed through which hydrogen is bubbled through the charge, removing these objectionable ingredients.

A Girbotol unit strips all hydrogen sulphide from the effluent gas stream as well as from the hydrogen recycle.

A re-run column has been provided so that the platformate can be split into two streams, light and heavy. The light complies with distillation requirements of aviation gasoline, while the heavy forms a most desirable ingredient for motor gasoline. The design capacity of the platformer is 3,800 barrels daily, but the unit has already operated with ease well over 4,000 barrels. In fairness to the designers and construction people, it should be mentioned that this unit went on stream immediately and more than met the guarantees and has scarcely been touched since. It has operated perfectly since the first day of operation. Indications are that catalyst life will far exceed that guaranteed.

If it were necessary to produce the maximum jet fuels, most of or all the heavy straight-run naphtha would be required for that purpose. In this event the light straight-run from the crude unit pre-fractionator can be charged to the platformer, making up the deficiency of normal charge stock, and still produce a maximum of aviation blending stock very rich in aromatics. This is because the light straight-run contains a mixture of normal and isopentane, cyclopentane, methylcyclopentane, cyclohexane, methylcyclohexane, C_7's and higher hydrocarbons from which more isopentane, benzole toluol and xylenes can be produced.

The effluent hydrogen stream from the platformer contains well over 85 mol % of hydrogen. A hydrogen storage drum is being installed to provide adequate storage for start-up hydrogen or to supply to other chemicals or process industries. Of course, it would be available should it be found necessary at a later date to go to the hydrogenolysis route. It is already indicative that in the not too distant future this hydrogen will be required. Excess hydrogen is produced at the rate of 750 to 900 net cu. ft. per barrel of charge, depending on the severity of cracking and the conditions of operation.

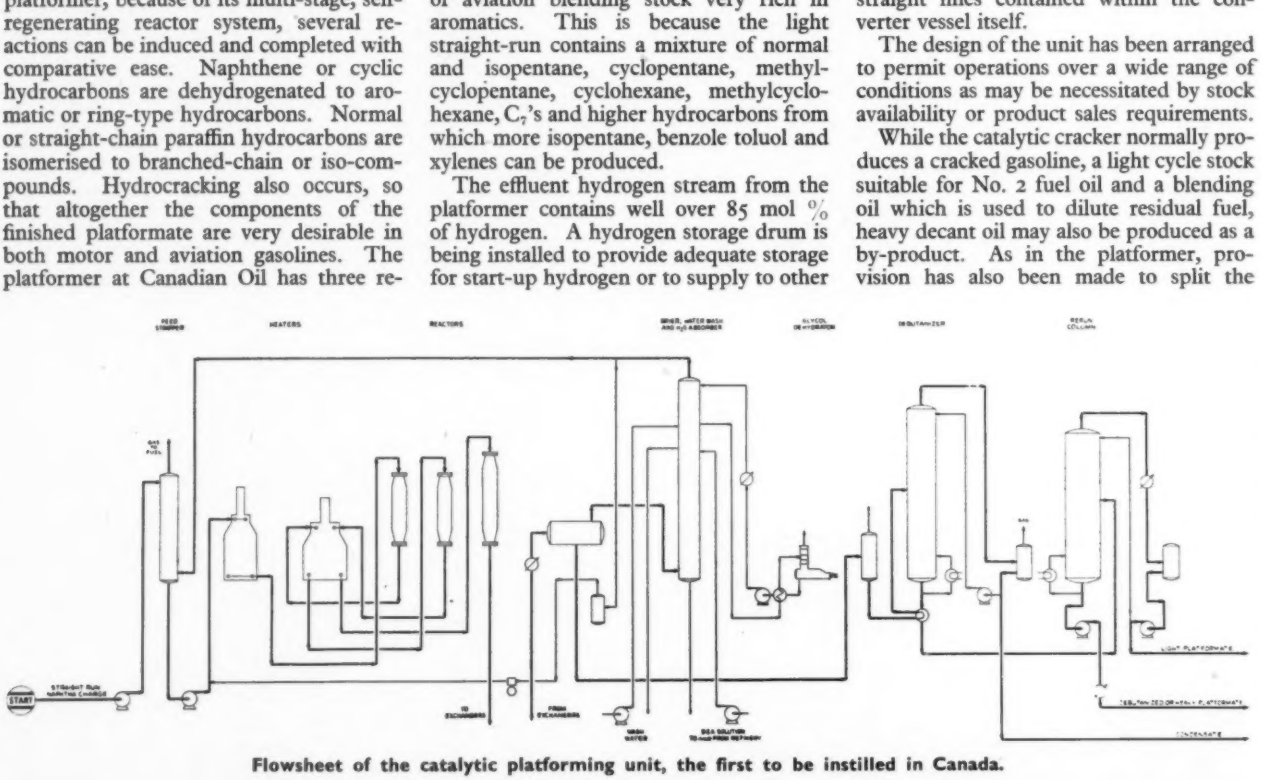
Catalytic cracking, gas recovery and catalytic polymerisation units

Three gas oil intermediate products from the crude unit are delivered directly to the cracking unit without being cooled. These products are converted catalytically into gasoline, domestic burner fuel and blending stock for bunker fuel. Variations in the gas oil production rate at the crude unit are balanced by diverting a portion through a cooler to a large storage tank. This also makes provision for an adequate inventory of catalytic cracking stock should the crude unit be shut down for repairs or turn-around.

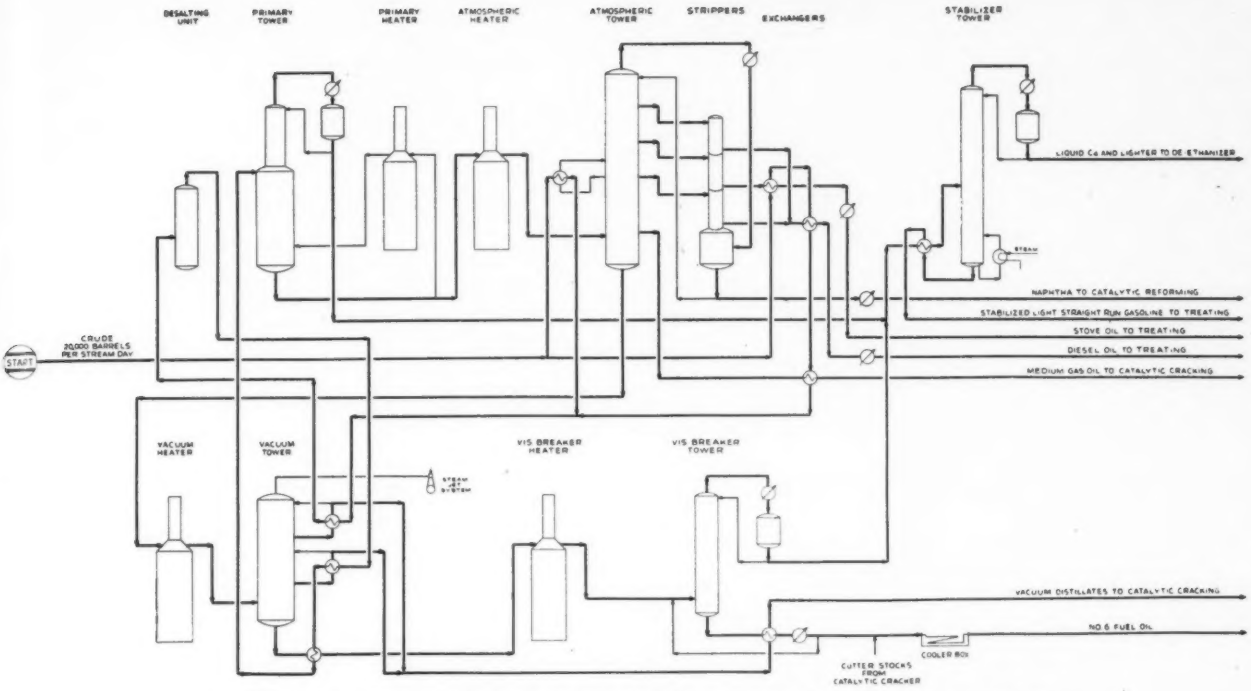
The cracking unit is the Kellogg fluid *Orthoflow* type in which the converter consists of both reactor and regenerator in a single vessel. The unit is the first in Ontario and is the third of such design by Kellogg. Many new ideas were incorporated in the construction of this unit, making it a 'last word' of its type. It represents a significant simplification of earlier designs by the elimination of all large external piping, expansion joints and valves. Both the spent and regenerated catalyst lines are straight lines contained within the converter vessel itself.

The design of the unit has been arranged to permit operations over a wide range of conditions as may be necessitated by stock availability or product sales requirements.

While the catalytic cracker normally produces a cracked gasoline, a light cycle stock suitable for No. 2 fuel oil and a blending oil which is used to dilute residual fuel, heavy decant oil may also be produced as a by-product. As in the platformer, provision has also been made to split the



Flowsheet of the catalytic platforming unit, the first to be instilled in Canada.



Flowsheet of the crude distillation unit in which five separate operations are carried out.

catalytic cracked gasoline stream into two parts, light and heavy, the light forming another source of aviation gasoline supply should future conditions warrant.

Compression of the gases produced in the cracking unit is effected by means of a turbine-driven centrifugal equipment and delivers the gases to an absorber stripper system designed for high C_3 retention. In this system the gaseous ingredients for manufacture of synthetic chemicals and synthetic rubber are retained to be later removed, separated and purified, then delivered by pipeline to Dow Chemical of Canada Ltd. and the Polymer Corporation. The unit, in conjunction with the gas recovery and catalytic polymerisation units, yields a propane product conforming to conventional LPG propane specifications and any excess not required by Dow is being sold as LPG product. A Girbotol unit is also incorporated in this group in order to ensure that all gaseous products are scrubbed free of hydrogen sulphide and carbon dioxide.

Process control

Nothing has been spared in the way of instrumentation and the control instruments are housed in two main control rooms, the one room taking care of the catalytic cracker gas concentration, catalytic polymerisation and Girbotol units, the other room the crude distillation unit, the platformer and a Girbotol unit. After careful consideration, semi-graphic panels were selected and placed in a setting of warm colours and soft lighting to permit instantaneous detection and correction of even the slightest irregularities in operation. Permanent-coloured line charts are installed over the instruments to assist the operators in visualising the entire processes and the exact condition at any given instant.

Wharves

Crude oil is unloaded from and products loaded into lake tankers at the new steel and concrete ship wharves, the first of their kind in the Sarnia area. These docks are so arranged and the piping so designed that they can be used interchangeably, and they are separated sufficiently to permit the operation of both without interruption. Crude oil can be unloaded at the rate of 15,000 barrels/hr. and products can be loaded at the rate of 5,000 barrels/hr.

Each wharf has facilities for bunkering ships with diesel and bunker fuel oil. Drinking water, compressed air and steam are also available. Two ramps or runways are provided so that ships can be provisioned by delivery trucks at the ship's side. Spillage of oil at the platforms is contained in built-in sumps on each wharf and is pumped together with bilge from ships to oil recovery equipment. Suitable lighting, racks, derricks, etc., are provided to facilitate handling of hoses and other materials incident to Great Lakes' traffic.

Products handling

The products made in the process unit groups which are delivered to the storage tanks are transferred or blended into separate tanks by a group of pumps contained in the transfer pumphouse. Shipment can be made by boats, tank cars or tank trucks.

Gasolines are specially processed and segregated to prevent storage and handling losses. They are blended to the desired grade immediately before shipment. The blending operation includes the combining of: (1) catalytic cracked gasoline, (2) platformate, (3) light straight-run naphtha, (4) butanes, (5) oxidation inhibitors, (6) anti-knock fluid, if necessary, and (7) the required dye colours. The entire blending operation is performed automatically by a special robot designed for this purpose and supplied by proportioneers. If desired, blending may also be performed without the automatic devices. Gasoline may be blended directly into tankers for shipment or to separate storage tanks for delivery by tank car or tank trucks at a rate of 5,000 barrels/hr. With the exception of visbroken residual, all products are treated continuously as they leave the process units. In other words, they are treated on their way to run-down and storage. Stove oil, diesel oil, No. 2 fuel oil and bunker fuel oil products are normally gauged and retested in their tanks and pumped directly to boats or to separate tanks for shipment by tank car or tank trucks at the same rate as gasoline.

Storage tanks

Over 2 million barrels of storage tank capacity is available in the refinery. Cone-roof, floating-roof, spheres, hemispheroid and bullet-type pressure varieties have been utilised. A large proportion of the steel plates that went into their construction was supplied by the Steel Co. of Canada.

Each tank was carefully designed for its intended services and provided with the latest protective devices. Freeze-proof

water drainage connections are provided, including a drainage piping system for cleaning or emergency evacuation into special handling equipment for recovery of all traces of oil before discharging the water. Adequate dikes are provided to contain any spillage. The dikes can be drained and the oil recovered.

Truck loading docks

Six large tank trucks may be loaded simultaneously from three loading spots under a steel-supported canopy with space provided for additional stations. Products can be delivered from the storage tanks to trucks at the rate of 500 imperial gal./min. per truck by means of swivel loading arms. Air eliminators and ticket printing meters are provided on all products except bunker fuel oil. The dock was originally designed to accommodate 4,000 imperial gal. trucks, but was modified in the later phase of construction to accommodate 5,200 imperial gal. trucks for gasoline. A gatehouse controls the flow of traffic and is provided with emergency controls for the pumping equipment.

Tank car loading

A grated steel structure provides space for 26 tank cars which may be filled with products from the refinery, including propane and butane. Products are delivered from separate tanks, by means of pumps, directly to the cars through swivel loading arms.

Each loading station has facilities for cleaning and draining the tank cars through a system of pipelines leading to the oil recovery equipment. The loading rack has been designed for future expansion as required.

Dual metering station

A separate canopy covers three sets of dual meters on all products shipped by pipeline to Dow and Polymer, and three sets of meters on materials returned to the refinery by these firms. The meters are installed dually so that each meter can be checked by its mate. Any meter may be removed from the line without disturbing the others. Calibrated meter runs are provided to ensure the greatest possible accuracy.

Main pump house

The building housing the principal pumping equipment is divided into three distinct compartments, each adequately heated, ventilated and fully equipped with fire protection devices.

Large inspection sumps are provided in this and the remaining two process unit groups to permit immediate diversion of effluent water to the oil separators. Suspected streams of water which may contain traces of oil are continuously diverted to the oil separators before delivery to Talfourd Creek which cuts across the west end of the refinery.

Noxious or undesirable gases which might contaminate the atmosphere are destroyed by burning.

Laboratory facilities

A very modern laboratory has been constructed and equipped for the chemical and research staff and houses the test engines, gas analysis equipment and all other equipment necessary to the successful operation of a modern refinery. Nothing has been spared to ensure the utmost in quality control and the development of new products and better methods of processing as time goes along.

Due to lateness of completion of the laboratory and the usual plant shake-down period, it is too early to table test data showing the effects to be achieved by varying the processing conditions. So far, the activities of the staff have been confined to product specification control, the many ramifications of inter-plant gas transfers and general organisation matters.

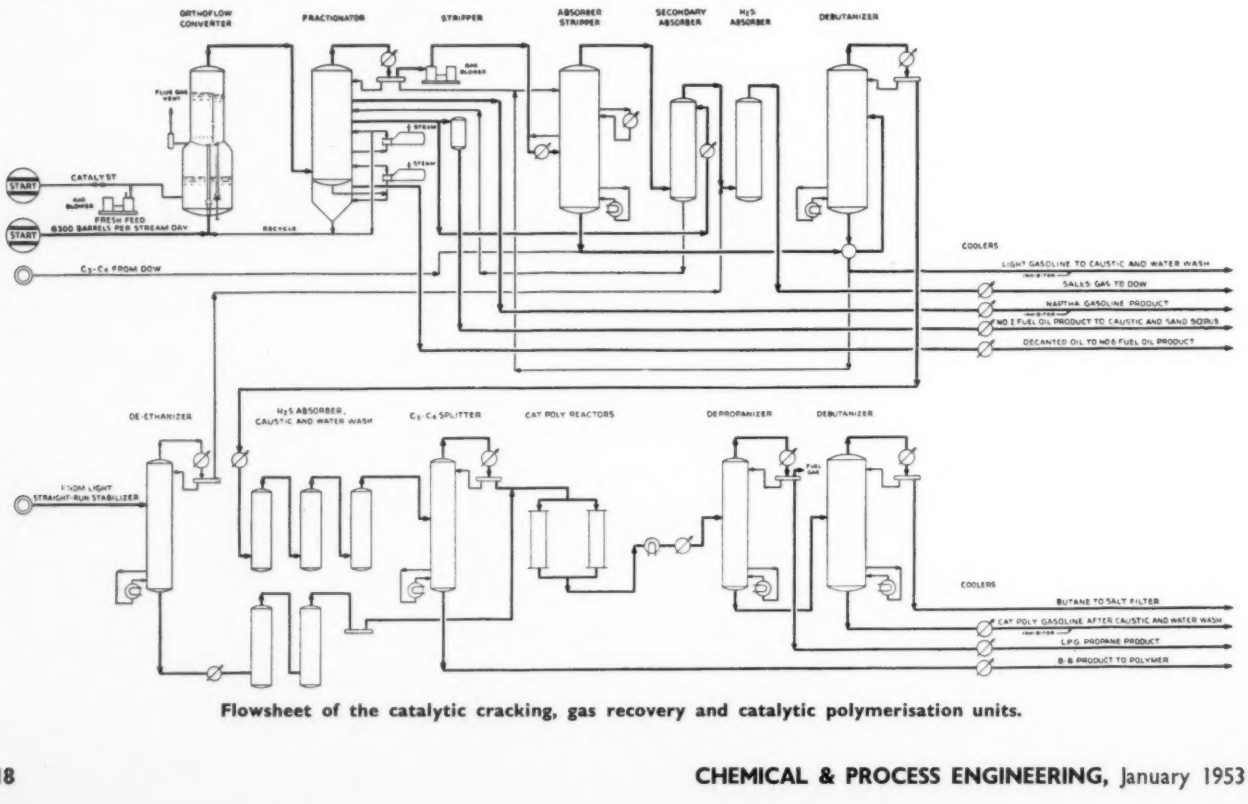
Pipe lines

In order to ensure against such contingencies as international agreements, a failure in the inter-provincial pipeline system, or the Great Lakes transportation system, an 8-in. crude-oil pipeline has been laid from the refinery and connecting to the network of pipelines in the United States. A 4-in. pipeline also links the new refinery with storage and shipping facilities still retained at the old refinery site in Petrolia.

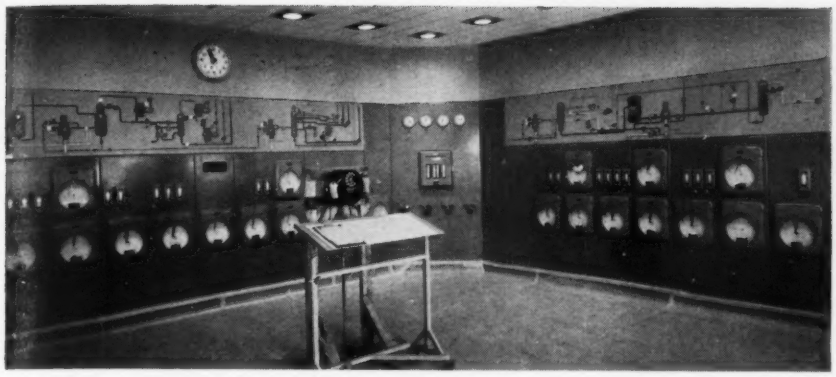
Steam generating and distribution

With the exception of the steam generated in the waste heat boilers at the catalytic cracker, all steam used in the refinery is generated in one of two B. & W. and Goldie McCullock boilers. Each boiler has a capacity of 100,000 lb./hr. of superheated steam.

The principal use of steam is for operation of the process unit groups and to maintain the required fluidity of heavy



Flowsheet of the catalytic cracking, gas recovery and catalytic polymerisation units.



Control room of the crude distillation unit, typical of the extensive instrumentation of the refinery.

products in storage tanks. A portion of the condensate from the steam is returned to the boilers and the balance made up with carefully treated water. The boilers and principal auxiliary equipment are housed and can be operated during a power failure.

Service air

A central refinery air supply system is located within the boiler plant consisting of separate air compressors for instrument air which is carefully dried. A separate group of air compressors is provided for maintenance and special services in the refinery. A spare group of compressors provides either instrument or service air under emergency conditions.

Water supply

The water supply system is an interesting feature of the refinery. Drinking water is secured from the city of Sarnia through a main some 15,000 ft. long. For process cooling water the untreated river water, which is rarely over 70°F., is used. A 7-ft. tunnel connects the shore intake to the main pump house, where three vertical motor-driven pumps are installed of 8,000 gal./min. capacity each. This water is delivered through a 36-in. steel main directly to the units. From this main is drawn the water for the steam boilers and processing at the refinery. The process wash water is clarified in the precipitator together with the boiler feed water. Motor-driven pumps deliver the process wash water in a separate main and the boiler feed is filtered, softened and pumped to the boiler plant. Chlorine for slime control is injected into the 36-in. main beyond the take-off for process water. All this equipment is in a separate building adjacent to the steam plant.

For fire protection, in addition to the chemical apparatus, there is a separate loop main with fire hydrants throughout the plant. An electrically-driven pump in the water treatment building draws water from the 36-in. main and boosts the pressure to the required limit. As a standby in case of power failure, there is a vertical diesel engine-driven pump at the main pump house. A study of the water supply reveals that there are five different water supplies in this refinery, *i.e.* city domestic, river cooling water chlorinated, process water clarified, boiler feed filtered and softened, and fire protection raw river water.

A feature of the cooling water supply is a 250,000 imperial gal. elevated water tower which maintains a constant pressure on the cooling water lines in the refinery and affords additional protection in emergencies.

Waste disposal

The drainage system is unique in that it consists of four separate sewers for the following:

(1) Sanitary sewage carried to a septic tank and double-drain sand bed.

(2) Storm water to the river with provision for low flows diverted to the waste treatment plant.

(3) Cooling water subject to oil contamination to the waste treatment plant.

(4) Cooling water with no oil contamination hazard to the river.

The sizes of sewers range from 12 in. to 48 in. in diameter.

To remove any waste oil from the various streams a new type of waste treatment plant was built. This plant consists of two circular concrete tanks 80 ft. in diameter and 8 ft. in depth with conical-shaped bottoms. Drainage water containing waste oil is delivered to a riser pipe with baffle in the centre of the tank, from where it flows radially to a circumferential weir after passing under a 6-ft. deep baffle plate which is also circumferential. The waste oil floats to the top of these tanks and is decanted off the surface by mechanically adjusted decanters and pumped to the slop tanks for recovery.

Service fuels

Undiluted viscosity broken crude oil residue produced in the crude distillation unit is normally used as fuel oil by the refinery itself. The oil is pumped through a looped pipeline to ensure continuity of operation. A further precaution includes the instantaneous service of a spare pump in the event of failure of the main pump. Oils which are reclaimed and are not suitable for processing are delivered in a separate pipeline for disposition in the boiler house. A gathering system of pipelines accumulates the residue gases from the process units and Dow Chemical and delivers them under pressure to the process units and boiler house for additional heat. Excess gas is automatically discharged to the flare stack, where it is burned.

Service chemicals

Adequate handling facilities are provided for the various catalysts, treating chemicals, inhibitors, dyes, anti-knock fluid and driers required for the refinery with minimum manual effort.

The principal chemical used is caustic soda which, being soluble in water, is specially treated in a novel process utilising carbon dioxide from the catalytic cracking unit. The treatment converts the spent caustic to an oily liquid which is carefully separated and burned in boilers and the remaining caustic is changed to a harmless salt.

Service power

All electricity for power and lighting is supplied by the Hydro Electric Power Commission of Ontario. A dual or looped system feeds the refinery with power made available from three independent sources for maximum reliability.

A sub-station transforms the high voltage to more suitable voltage before distribution in an underground duct system. Distribution is radial and not looped to the various users. The sub-station contains a dual set of transformers which are interlocked to permit automatic transfer from one transformer to the other in the event of failure of one. The power received at the area of use is further reduced in transformers to the voltage required by the equipment or lighting.

The system is completely explosion-proof in all areas considered hazardous. A small emergency steam turbine-driven generator installed in the boiler house provides lighting and power to operate control instruments in the refinery in case of emergency.

Plant protection devices

Relief valves are provided on all pressure vessels. These are piped to a flare stack and any light vapours burned automatically. Heavy oil vapours and liquids are piped to a separate quench tower which liquefies the vapours automatically by means of water. A pump returns the oily water to special tanks for recovery of oil.

A complete pipe loop system encompasses the refinery with water for fire-fighting. Water is made available under high pressure from the motor-driven pump operating from the elevated water tank and the cooling process water system. A spare diesel-driven fire pump supplements the main pump. Adequate foam systems are installed for the protection of all tanks and to handle fires within the process units.

Portable chemical fire extinguishers are located at strategic points in the various buildings, or steam snuffing is provided.

Complete water spray systems are installed in the anti-knock fluid storage building. Buildings not otherwise protected are sprinklered.

The fire station building houses a mobile fire engine, foam trailer carts, a patrol jeep, hose and drums containing foam liquid compound and dry chemical. For convenience an auxiliary building at the opposite side of the refinery supplements the hose and chemical contents of the fire station.

Communications

All important points of the refinery are closely knit together by means of an enunciator and an automatic telephone communication system which permits contacts to the outside. Separate systems to Dow and Polymer permit direct communication with strategic operating points in the refinery. In an emergency an independent network permits transmission of instructions to personnel at selected points.

Miscellaneous services

The refinery is laced with roads, streets and access ways. All roads are elevated to permit the crossing of pipelines which are laid on specially designed and patented supports near the ground.

A railroad siding services the refinery's shipping and materials requirements. Three pipe-supporting bridges were found necessary to carry the many pipelines across Talfourd Creek to and from the water pump house and the other river front facilities.

Training programme

During the planning stages of the project it was realised that additional engineering, technical and supervisory personnel would be required as well as operating personnel. Shortly after the commencement of construction this technical and supervisory staff were acquired and gathered together at Petrolia, the site of the old refinery, in a classroom specially prepared and equipped with files, desks, tables, drawing racks, blackboards, etc.

Preliminary discussions were held with the contractors' engineers concerning the various processes. This was followed by actual observation of the operations of similar processes in refineries both in Canada and in the United States.

The remaining step-by-step programme included the preparation of a larger classroom in temporary buildings at the new refinery, where additional equipment, such as a projector, blueprinting machine and special wide armchairs for the operating personnel, was provided. The technical and supervisory personnel then took over the lecturing and teaching of the operating personnel and consisted of:

(1) Intensive blackboard instruction.

(2) Study of flow diagrams with attendant motion films.

(3) Additional discussion with contractors' engineers concerning the written operation instructions and safety measures.

(4) Detailed study of all mechanical and control features of the entire refinery.

(5) Participation in preliminary and eventually full operation of the various components.

New projects in planning stage

Government and petroleum industry leaders estimated last year that Canada needs 100,000 barrels per day of additional refining capacity. Canadian Oil's new plant will supply one-fifth of that deficiency. Indications are that the entire output of the new refinery from the first full production day will be required for civilian and defence uses.

Purchase of land for expansion even before levelling of the adjoining refinery site began was an application of Canadian Oil's policy of long-range planning. In short perspective, the firm's feat in more than doubling its capital assets in a little more than two years may foreshadow new construction and expansion projects already under study.

Rayon and Aluminium to be made in Australia

TWO new projects to be undertaken in Australia are the manufacture of aluminium and rayon for the first time. The aluminium plant is being built at Bell Bay, Tasmania, with a capacity of 13,000 tons p.a. It is due to be in production in 1954.

The establishment of Courtauld's plant at Tomago in New South Wales, with a capacity of 6 million lb. of viscose and 3 million lb. of acetate yarn per annum, will give Australia a local source of these yarns. Results of research work conducted in utilising Australian materials for the production of viscose yarns promise to be successful. The raw material for the production of cellulose acetate yarns will probably also be of local origin. Further developments are planned by Courtauld's and other companies.

This information is given in a new document, 'The Structure and Capacity of Australian Manufacturing Industries,' prepared by the Division of Industrial Development of the Department of National Development. Other industrial projects described in this book are:

Coal. The major programmes of the Joint Coal Board and of the states are reflected in the marked improvement in coal production in the last 18 months. Production of black coal in 1949-50 was 14,900,000 tons and in 1951-52 19,400,000 tons; of brown coal, 7,637,000 tons in 1949-50 and 8,112,000 tons in 1951-52.

Iron and Steel. The completion of a blast furnace at Port Kembla with a capacity of 500,000 tons p.a. has increased iron making capacity by 30% from 1,760,000 tons p.a. Another blast furnace, with a capacity of 290,000 tons p.a., will be erected at Newcastle in the next few years. These developments are being paralleled by major developments in steel making capacity and in the rolling mills.

Alkalis. The Australian heavy chemical industry is developing quickly and capacity for production of alkalis has been doubled. The capacity to produce ammonium sulphate will be increased from 80,000 tons to 130,000 tons annually by 1955.

Petroleum. The major oil companies are beginning construction programmes which will increase Australian annual refining capacity from 850,000 tons to 6,500,000 tons by 1956. This will involve equipment and processes not previously seen in Australia.

Paper and paper board. A major programme was initiated in 1945 to increase Australian capacity to produce paper and paper board from 195,000 tons to 400,000 tons p.a. in the next decade. This will enable local production of paper and paper products equivalent to imports of £35 million annually. It will, however, require further import of long-fibred pulp for mixing with the short-fibred local pulp.

Lead. It is proposed to increase capacity for lead production from 160,000 tons to 225,000 tons in the next few years.

Zinc. Effective capacity for and the level of production of zinc will be increased from about 80,000 tons to slightly in excess of 100,000 tons p.a.

Copper. The completion of the copper smelter at Mt. Isa in Queensland, designed to give an output of 18,000 tons of blister copper p.a., will more than double Australian production of copper in recent years. (Production in 1950-51 was 10,930 tons and in 1951-52 15,856 tons.) It is expected to be in operation by 1953 and producing to capacity by 1954.

Cement. Australian annual capacity for cement production has been increasing at a rapid rate since the end of the war and further substantial expansion is planned. Capacity has been increased from 1,310,000 tons p.a. in 1948 to 1,520,000 tons in 1952, and will be increased to 2,300,000 tons p.a. in the next four years.

Electric power. For several years all states have been making major efforts to increase generating capacity, although recently finance has become a problem. Capacity of 2,042,000 kw. in 1949 had been planned to reach approximately 4,500,000 kw. by 1956. This expansion is now likely to be delayed.

Chemicals Direct from Coal

A PILOT-PLANT process for the direct production of chemicals from coal has been developed by the Coal Research Laboratory, Carnegie Institute of Technology, Pittsburgh. This provides data for large-scale commercial production of such chemicals, a proposition which will appeal strongly to the chemical industry. According to N. W. Franke, *et al.* (*Ind. and Eng. Chem.*, 1952, **44** (11), 2784-2792), all aromatic chemicals produced at present from coal are obtained as by-products from the coking of coals for the steel industry. Large increases in these chemicals do not appear probable because of the high cost of by-product coke oven installations plus the fact that steel production is at peak capacity. A process operated independently of steel operations and starting directly with coal would help solve this problem.

The first laboratory experiments with oxygen gas and alkali were carried out in a 1-litre, nickel, rocking autoclave and it was discovered that, by liquid-phase oxidation with oxygen gas in an alkaline medium, about 50% of the carbon of bituminous coal could be converted into water-soluble organic acids. In the case of high-rank bituminous coal, nearly 40% of the carbon appeared as polycarboxylic aromatic acids. Alkali concentration was of great importance. In water alone the reaction resembled a combustion, producing negligible amounts of the desired soluble acids. At 1.5 *N* a maximum yield of humic acids was reached which, on further increase in alkali concentration, was decreased by further oxidation to give additional quantities of the desired soluble acids. It was found that attempts to oxidise materials higher in rank than a 500°C. coke proved unsatisfactory. The 500°C. coke and low volatile Pocahontas coal were outstanding from the point of view of yield of aromatic acids. As this Pocahontas coal was readily available, it was used in the larger-scale work.

The reaction was studied in three types of reactors: a small rotary-type pressure vessel with a capacity of about 1 lb. of coal per batch; a small packed-column type of continuous reactor; and in an internally stirred 25-gal. pressure vessel with a capacity of 15 lb. of coal per batch. The first reactor constructed of a piece of 6½-in. i.d. Shelby steel tubing with ½-in. wall, showed no evidence of caustic embrittlement, indicating that mild steel could be used in an emergency for this type of reaction. From a study of the continuous reactor it was demonstrated that, at 225°C. and 600 p.s.i. gauge, satisfactory rates of oxidation from the humate to the desired soluble acid stage could be attained, and concluded that with suitable pumping equipment slurries of coal could be circulated and the oxidation carried out continuously in one stage.

The pilot-plant runs were made in the third type of reactor, a 25-gal., vertical, batch autoclave, because of the greater flexibility of the batch compared with the continuous type. This allowed for the chemical characterisation and commercial evaluation of larger amounts of the acids. This reactor, constructed principally from nickel-clad steel or nickel, was 19½ in. i.d. and 30 in. deep. It was designed for a pressure of 1,000 p.s.i. gauge at temperatures up to 300°C. An internal nickel coil could be connected by valves to a high-pressure steam line for heating or to a cold water line for cooling. Charging, discharging and oxygen introduction were carried out by a nickel tube leading from the outside to a set of appropriate valves. An electric turbostirrer agitated the autoclave contents. Heating was provided by 34 220-volt, 750-watt *Chromalox* heaters. *Inconel* safety discs, resistant to ammonia and to sodium hydroxide, were installed.

In the experiment, 15 lb. of Pocahontas coal pulverised to −100 mesh was stirred with 45 lb. of sodium hydroxide and 15 gal. of water in an external hopper, then pumped into the autoclave and heated to about 160°C. The heating steam was then shut off, the electrical heaters turned on, and oxygen introduced. The heat liberated by the exothermal reaction of the oxygen with the coal raised the temperature of the system to 270°C. in less than 30 min., where it was maintained by an input of 3.8 to 5.7 kw. to the *Chromalox* heaters. The oxygen flow was regulated to maintain the total pressure on the system at 900 p.s.i. gauge. The conditions of 270°C. and 900 p.s.i. gauge were maintained until a total of 50% of the carbon of the coal was converted to carbon dioxide and the remainder was soluble in alkali as the humic acid stage. During oxidation about 1.63 lb. of oxygen was consumed per lb. of coal charged.

After rapid cooling below 100°C., the autoclave contents were forced into a 55-gal. drum equipped with stirrer and heating coils. The 18 gal. of product were diluted with water to 22 gal. and filtered to remove ash, some sodium carbonate, and any insoluble carbonaceous residue. The filtrate was then poured into about 50 lb. of 95% sulphuric acid and the acidity adjusted to 1 *N*, the optimum normality for extraction. A pitchlike material formed on the surface and was removed and re-oxidised in the autoclave. It gave good yields of high-quality aromatic acids, indicating that it represented an intermediate stage in the oxidation process. The acidified solution was then extracted twice for 2 hr. at 40°C. with two-thirds its volume of methyl ethyl ketone in glass-lined Pfaudler extraction tanks, fitted with stirrers (150 r.p.m.) and heating coils. The methyl ethyl ketone was practically insoluble in the saturated solution of sodium sulphate encountered here. An efficiency of over 85% was consistently obtained in the two-stage extraction. The methyl ethyl ketone was then distilled from the extract until the residue reached the consistency of 50 to 70% aromatic acids. This syrup was dried and the dried porous friable mass of the acids was readily powdered in a ball mill. This mixture of acids recovered from the process formed a hygroscopic, friable, yellowish-brown mass. About a third of the oxidation products were benzenecarboxylic acids. These are strong organic acids and react with alcohols to form esters. The mixture of acids was found to be very soluble in water and some had the interesting property of forming water-soluble calcium, barium and heavy metal salts. With possible increases in efficiency of recovery, the weight of recovered acids would be more than half the weight of coal used.

In June 1947, a report compiled by the Scientific Design Co., New York, estimated that, at a production capacity of 1 million lb. p.a., a project using the new process would be self-supporting although non-profitable and that, at 10 million lb. p.a., the total production costs per pound of coal acids would be only about half the market price of phthalic anhydride. These acids could, therefore, be produced economically. The main factors affecting the cost of the entire operation appear to be the alkali recovery and the availability of tonnage oxygen at low cost, as well as the value of the recoverable by-products.

Coal acids may be used as plasticisers, lubricants, petroleum de-emulsifiers, substitutes for other organic acids and possibly in the production of glyptal-type resins.

Carbon chemical plant. The *Delanium* graphite heat exchanger made by Powell Duffryn Carbon Products Ltd. is fully described in a new brochure. The exchanger is especially designed to meet highly corrosive conditions. The heart of the unit consists of a block or cube of *Delanium* graphite perforated by a series of holes running through the block in alternate rows at right angles to each other. The graphite cube is placed under heavy compression by cast iron clamping plates so that the graphite material is heavily prestressed, and even when in operation retains a net comprehensive stress. The graphite cube is thus like a honeycomb through which liquids or gases to be heated or cooled are passed, separated from the heating or cooling medium by only a high conducting graphite wall.

Automatic controllers. A comprehensive catalogue of automatic controllers has been issued by Negretti & Zambra Ltd. The devices described include controllers for temperature, pressure and humidity. Details are also given of a number of valves, air compressors and accessories.

Norwegian Fatty Acids Plant

SANDA FABRIKKER A/S, Sandefjord, Norway, who have been making hardened edible and technical fats, refined marine oils and fatty acids since 1935, have recently built a large plant for the production of fatty acids by the Armour process, devised by the American firm of that name. The firm have secured from Armour an exclusive licence in Scandinavia to produce fractionated, distilled fatty acids by a technique resembling that of petroleum refining. The acids will be sold under the name *Safacid*.

The new distillation unit shown in the centre of the photograph will have an annual throughput of about 10,000 tons. As the unit is of a very flexible design, any oil or fat can be used as raw material. In animal and vegetable oils and fats the fatty acids usually occur in combination with glycerol in the form of glycerol esters, called glycerides.

The first stage in the process is to split the oils or fats in high-pressure, stainless steel autoclaves:

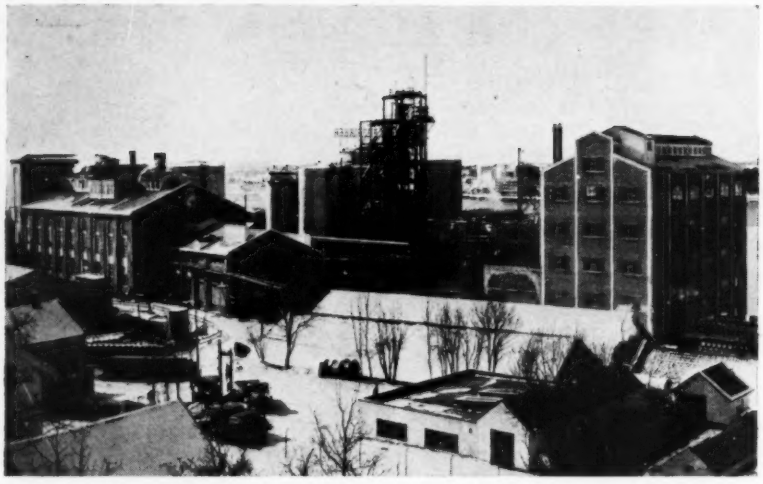
Glyceride + Water ⟶
Fatty Acid Mixture + Glycerol

The fatty acid mixture is carefully washed and centrifuged and is then stored in tanks prior to distillation. From the storage tanks the fatty acid mixture is pumped at controlled rate to the fractionating tower.

A triple-column still system is used. All three stills are built of special stainless steel and each column is complete with *Dowtherm* heat exchanger, tube jet, reflux accumulator, control gear, instruments and pumps. The object of the process is to remove fractions of increasing boiling point as the fatty acid mixture flows through the column series. The columns are maintained at different levels of vacuum and temperature, and varying input of superheated stripping steam is used. It is possible to operate the column series in different ways, and three, four or five fractions can be obtained as desired.

Automatic control is used on the distillation unit and all the instrumentation is centralised in a control room. The whole unit, which is a complex installation about 100 ft. high, can be operated, controlled and supervised from this room. All the pumps are centralised in a pump room, and to ensure continuity of operation they are all installed in duplicate.

The finished-product tank-farm consists of 14 aluminium tanks, each of about 100 tons capacity, where the distilled fatty acids are stored under inert gas. The liquid and low-melting acids are supplied in 200-litre iron drums, coated inside, and wooden barrels. The high-melting acids can be supplied in flakes filled in paper bags or other suitable packing. To large consumers the fatty acids can also be supplied in bulk by tank vessel or in car lots.



Plant at Sandefjord for the production of fractionated distilled fatty acids.

The fatty acids can be supplied in commercially pure qualities up to 90 to 95% purity or in mixtures according to customers' requirements.

With this new fatty acid plant, combined with the refining and hardening plant, which since the war has been extended and modernised, Sandar claim to be able to meet almost any requirements in the field of fatty acids.

NOTE—*In Britain the Armour process is operated by Hess Products Ltd., at Littleborough, Lancs. A description of the plant appeared in this journal, February, 1950, pp. 69-71.*

Stainless Steel Clad Copper Vessels

WITH few exceptions stainless steels are the poorest heat conductors of all constructional metals. Their conductivity is illustrated by the fact that in stainless heating vessels the heat spreads so slowly that it causes a hot spot at the point nearest the source of heat. To solve this problem, stainless steel clad with copper is produced in one sheet, making a finished article with the high thermal conductivity of copper and the corrosion and high temperature resistance of stainless steel. The copper core, which is usually about 30% of the total thickness of the clad sheet, serves to spread the heat at the instant it strikes the sheet. No hot spot will then be formed which might cause buckling, warping or cracking.

Tests have been carried out in America to determine the lateral heat conductivity of various metals and are described by J. Kinney in *Product Engineering*, 1952, **23** (4), pp. 129-133. Strips of the metals under test were placed in a furnace and extended out through a door. All the strips were of uniform size, 2 x 26½ in. It was found that the highest rate of lateral conductivity occurs when the copper is of about one-half of the total thickness of the sheet. Comparing a sheet of 50% copper core stainless clad, and a sheet of solid copper, it was found that the lateral conductivity of the copper core stainless clad sheet was higher than that of the solid copper. In the clad sheet the heat cannot escape from the surface as quickly as from the solid copper sheet. The bright stainless steel surface is also a relatively poor radiator of heat. The heat insulation and the slower heat radiation of the stainless clad sheets therefore caused a higher temperature differential between the advancing "heat wave" and the cold metal.

In general, the corrosion resistance of the stainless steel cladding will determine the corrosion resistance of the laminate. However, because of the relatively low melting point of copper (1,981°F.), this clad metal should not be specified for applications where the maximum temperature will exceed 1,800°F. If the metal surface is exposed to a chemical-laden atmosphere, the maximum allowable temperature may be considerably less. Copper exposed to air begins to oxidise at about 750°F., forming a semi-protective film that retards the penetration of the oxidation. If protection against oxidation of the copper is required the edge of the clad metal is pickled, the copper being eaten back $\frac{1}{32}$ in. The stainless steel edge is then rolled to pinch the edges together, which are then welded. An alternative method can be used employing a calorised process. Calorising diffuses aluminium into copper to form an alloy of high oxidation and corrosion resistance.

The workability of stainless clad copper presents no unusual difficulties and as it is approximately the same as that of the cladding it can be machined by the same procedure as for the cladding metal although the copper core gives the laminated material greater ductility and formability.

Chemicals, Coal and Oil

AN AMERICAN ANALYSIS OF THE STERLING AREA

BASIC facts about chemicals, coal and oil in Britain and other sterling area countries are given in a new book* called 'The Sterling Area—An American Analysis.' It is published by the Mutual Security Agency Mission to the U.K., but, it is pointed out, the title should not be taken to mean that the book expresses an American point of view, official or otherwise. The material was originally prepared in order to provide a factual basis for the Mission's study of the U.K. trading and financial situation and the economic relations between the U.K. and sterling countries on the other. The book, containing nearly 700 pages amply illustrated by maps, charts and tables, is divided into three sections. The third section, of some 250 pages, is devoted to the main commodities in the sterling area trade, namely coal and chemicals; petroleum and petroleum products; iron and steel; non-ferrous minerals; cereals; fats and oils; other foods; beverages and tobacco; machinery and vehicles; cotton, synthetic fibres and products; wool and other fibres and products; rubber, skins and products; and, finally, wood, pulp and paper. Although much of this information is already well known to people in the industries concerned, the book contains many useful industrial statistics and economic facts, some of which are given below.

CHEMICALS

Britain is the second largest chemical producer, the U.S. being the largest. Germany, France, Belgium, Canada and Russia are also big producers of chemicals. In addition, manufacturers in these countries have subsidiaries in other parts of the world—British firms, for example, having more than 100 branches (or associated plants) operating outside the U.K. (mainly in the overseas Commonwealth countries).

Prices

Chemical prices have not increased as much as the prices of commodities generally. In the U.K., prices have been about half as much again since the war as in 1934-38, while, by 1950, prices of all commodities had increased by one-and-a-half times. Similarly in the U.S.A. the index of chemicals prices was up by a third in 1949 and 1950 over 1934-38, while the index for commodities in general almost doubled. While the production of inorganic chemicals has expanded at the same rate as general industrial production, the output of organic materials has been growing at a greatly accelerated rate and it is chiefly in this field that new products are being marketed which tend to become cheaper as their development continues, thus helping to keep prices down.

Raw materials

Coal is fairly plentiful in all the major chemical-producing countries. Petroleum, an alternative source of hydrocarbons, is not a significant natural resource of Britain nor of other Western European countries. Refining capacity has expanded greatly in Britain and Western Europe since the war, thus creating a great new source of chemicals and raw materials.

Supplies of salt are widely distributed throughout the world and there are large deposits in England, Germany and Poland. Calcium carbonate is also plentiful all over the world in various forms, including limestone, the form chiefly used in the chemical industry.

Of the three essential plant growth elements—NPK—nitrogen is used in the form of nitrates or ammonium salts obtained from the air by the Haber process. Phosphate rock occurs in many parts of the world—the U.S.A. has enough to meet its own requirements, but the U.K. has none and imports the rock mainly from North Africa. The U.S.A. is self-sufficient in potassium salts and exports them to Canada and the West Indies. The U.K. relies on imports from Germany, France, Spain and Israel, the largest deposits in the world being those at Stassfurt in Germany. Recent discoveries of potassium salts in Yorkshire may alter the U.K.'s situation if these deposits can be developed commercially.

The U.S.A. produces 90% of the world's sulphur and, out of 4 million tons retained for home consumption in 1950, 3 million were used for the manufacture of sulphuric acid. The largest consumption of sulphuric acid is in the fertiliser industry; thus about 35% of U.S. production, 50% of U.K. production and 75% of Canadian production are used for this purpose.

International trade

Britain's pre-war chemical exports were larger than those of the U.S.A., but since the war the U.S.A., with a volume approximately five times as great as in the period from 1934 to 1938, was by far the largest exporter in the world. Britain's production in 1950 was double that of pre-war years, but its exports increased by only about 50%. Nearly half went to the overseas sterling area and about a quarter of these went to India and Pakistan. The non-sterling O.E.E.C. countries and their dependencies took a fifth before the war and after the war this increased to about a quarter. In 1949-50 exports of chemicals were 3% of Britain's total exports to the U.S.A.; they amounted to 4% in the 1934-38 period. The U.S.A. was the chief market for British coal tar oils, taking between 60 and 70% of total exports between 1945 and 1950; approximately half the U.K. exports of chemicals to the U.S.A., both before and after the war, consisted of these oils.

The U.S.A. exported chemicals valued at $703 million in 1949-50. Canada was the largest single market, receiving 16%, and the sterling area took the reduced proportion of 15%, as compared with its pre-war 21%. This reduction was entirely due to the halving of the proportion going to the U.K. Exports to the non-sterling O.E.E.C. countries amounted to $133 million, a drop from $165 million in 1948. Chemicals were the second most important export from the U.S.A. to the overseas sterling area countries, amounting to 8% of the total in 1949-50.

Imports of chemicals into the chief overseas sterling area countries account for between 2 and 6% of their total imports both before and after the war. In the post-war period about half the Australian imports came from the U.K., the total imports of chemicals being valued at £A11 million in 1948, rising to £A12 million in 1950. India imported 289 million rupees-worth of chemicals in 1948-49, but this was reduced to 161 million in 1949-50. New Zealand spent £NZ6 million on chemicals in 1948 and 1949 and South Africa spent £8 million and £9 million respectively in those two years. No other sterling area country had imports above £4 million. The largest overseas sterling area exporters are Australia with over £3 million in 1948-49 and South Africa with over £2 million in 1949.

COAL

In 1948 the U.S.A. used 530 million metric tons of coal, the U.K. 201 million tons, W. Germany 77 million tons, France 63 million tons, Belgium 27 million tons and Poland 45 million tons.

The tendency is for more coal to be used indirectly through the production of electricity and gas. Of total consumption in the U.K. in 1949-50 public utility undertakings took 29%; approximately 16% was used by power stations and 13% by gas works. About 7% went to the railways. Coke ovens consumed 12% and other industrial consumers 22%. Domestic consumption accounted for 19%.

Production

Not all the world's known coal deposits are worked. In the coal-producing countries of Europe, including the U.K., the seams tend to be deeper, thinner and more irregular. Although the machines used commonly have to be of a different design from those used in American mines, the

*_The Sterling Area: An American Analysis_, prepared by the Mutual Security Agency Mission to the United Kingdom. H.M.S.O., pp. 672, 21s. net.

trend to mechanisation is strong. In some Continental countries the process was well advanced before the war, particularly in German and Dutch mines, where output per man-shift rose by 99% and 112%, respectively, between 1924 and 1936. In the same period U.K. output per man-shift rose by only 31%. In the U.K. progress was most rapid between 1938 and 1948, the proportion of the total output mechanically cut increasing from 60 to 76%, and the proportion mechanically loaded from 54 to 78%.

Opencast mining has also been employed in the U.K. in the war and post-war periods to supplement the supply of deep-mined coal; 8 million long tons were obtained in 1945-50.

The war disastrously disrupted coal production in Europe. About 35% of the German mines were destroyed or damaged, maintenance work had been neglected in the Czech and Polish mines, and a number of French mines were badly damaged. In 1949 the total output of European pro-producers was still 50 million metric tons less than it had been pre-war. All countries had manpower problems to solve and productivity was low owing to lack of materials and equipment. The mining industry in the U.K. did not have to contend with the effects of direct war damage, but had other problems of a more deep-rooted kind.

During and after the war attempts were made to increase productivity in Britain by schemes to co-ordinate the industry and to increase mechanisation, equipment to the value of £5.5 million being installed by the end of 1945.

The U.S.A. is the largest producer of coal, mining approximately 40% of the world total of roughly 1,500 million metric tons in 1948. The U.K. contributed 14% to the total. Germany, France and Belgium produced 6%, 4% and 2%, respectively. Poland and the U.S.S.R. together are believed to have produced about 20%, while Japan supplied 2%. Among the overseas sterling area countries which produce coal are India, Southern Rhodesia, South Africa, Australia and New Zealand. As a whole these countries are self-sufficient, while some have small export surpluses, notably South Africa and India.

All the main producing countries have supplies of bituminous coal, while the U.S.A., U.K. and Belgium are the principal suppliers of anthracite. The main producers of lignite are Germany, Czechoslovakia and Hungary. Coal is an exhaustible resource, but the world's reserves are enormous. Among the W. European countries Germany probably has the largest total reserves. Britain, in spite of its long history of mining, still has reserves which are only slightly smaller than those of Germany and are of better quality. Although many of the mines at present operating in the U.K. are old and most of the coal that can be economically reached from the existing shafts has already been mined, there are still good, new seams to be opened up in many parts of the country when the necessary capital is forthcoming.

International trade

Pre-war the U.K. was one of the most important suppliers in the European coal market and 65% of its exports went to this area. The U.K. lost its European markets after 1940, and its exports were considerably reduced thereafter.

One of the most striking features of the international coal trade since the war has been the large exports from the U.S.A. to Europe. The cost of this coal, which had to be paid for in dollars, was high, including, as it did, heavy freight charges. U.S. exports to Europe reached a peak of 37 million short tons in 1947.

PETROLEUM

In the world as a whole, the oil used in 1947 was equivalent in its energy content to about 70% of the coal consumed; in the U.S.A. the two fuels were about on a par with one another. The global energy total for oil plus natural gas was almost equivalent to the energy contained in all the coal that was mined; the U.S. oil and gas total was considerably greater than the corresponding energy figure for coal.

The total amount of petroleum that had been produced in the world up to the end of 1948 was 58,000 million barrels and, of this, 64% had come from wells in the U.S.A. In that year, for the first time, the U.S.A. became a net importer. Although still supplying the bulk of its own requirements, having proved reserves equivalent to 14 years' consumption and undoubtedly having many pools not yet discovered (which may contain two or three times as much as the proved reserves), the U.S.A. may be expected to become increasingly dependent on imports.

The simple stills originally used to refine oil have been largely replaced by more elaborate equipment or by complex catalytic cracking units. In the U.S.A., cracking capacity, designed to maximise petrol output, constituted 57% of the total refining capacity in 1950; in the rest of the world it was only 30% of the total.

International trade

The rising demand for petroleum brought a rapid expansion of the oil industry after the second world war. In Britain, from 1947 to 1950, £55 million went into the building of petroleum refineries; when the programme is completed in 1953 British oil refinining through-put capacity will be over ten times greater than pre-war.

The effects of oil transactions on the sterling area's dollar balance of payments are difficult to determine exactly, but they are known to have been responsible for a larger part of the hard currency drain in the post-war period than any other single category of expenditures. While crude production, refining capacity, transport facilities and plants for the production of oil equipment were being expanded, heavy dollar expenditures were unavoidable. Before the end of 1949, however, opportunities for dollar savings were beginning to appear.

The ' dollar content ' of oil supplied by American companies in 1949 was about 75 to 80% of its value. This was lowered to about 40% in 1951 and is being progressively lowered to a general level of about 30% by 1954. It is expected that by 1954 the sterling area will be getting a third more oil than in 1949 at a dollar cost of a quarter less.

Before the war 89% of Britain's petroleum import expenditures were for refined products; in 1950 they were 62% of the total. The U.K. obtains most of its lubricating oil imports from the U.S.A., but these constituted only about 10% of total American exports. Overseas sterling area countries take more than a quarter of the lubricating oils sold abroad by the U.S.A.; Western Europe takes nearly a third.

Engineers' thesaurus

Over 8,000 detailed designs and drawings of mechanical movements, parts, devices, tools and assembled machinery are classified for quick reference in a new American book.* These include screws, nuts, clamps, frames, chains, levers, gears, cranes, conveyors, pumps, valves, engines, and appliances for every engineering and industrial application.

The main object has been to present the maximum number of illustrations and this has limited the descriptive text to a minimum. The publishers claim that the book contains the largest collection of such items ever assembled.

Each type of machine element is clearly reproduced and identified and, where necessary, an explanation of the method by which it accomplishes its particular function is given. Sketches of related parts are logically grouped. There is a 14-page index containing over 1,000 entries of the various groups and elements.

The book is divided into two parts, namely, statics and dynamics. The first part covers fasteners, adjusting devices, supports and structures. The second, basic mechanical movements, elevators, derricks, cranes, conveyors, transmission of liquids and gases, combustion, prime movers, transportation, industrial processes, electrical appliances, comfort heating, cooling, and air conditioning. It has been compiled for the engineer and inventor who need only an outline of an idea for their inspiration or design. The underlying principles are emphasised and not structural details such as would appear in a textbook of machine design.

**The Engineers' Illustrated Thesaurus*, by H. Herkimer. Chemical Publishing Co., 1952. Pp. 572, inc. index. $6 net.

Plant and Equipment

Glandless pump

One of the major problems of pump designers has been to provide a stuffing box capable of satisfactory operation under the arduous present-day working condition, the difficulties of packing a gland 'leak free' being almost insuperable in certain cases.

The Howard permanent magnet coupling, made by Hydraulic & Mechanical Developments Ltd., is claimed to enable the drive to be transmitted through a solid metal sealing shroud, thus disposing with all forms of shaft seal and making possible a completely glandless pump.

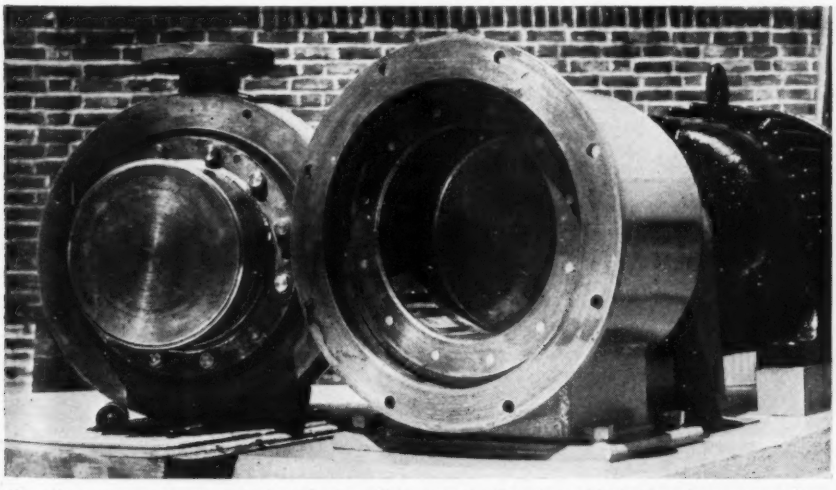
In the present design of coupling, the driving member consists of a ring of permanent magnets of horseshoe shape mounted in a non-magnetic housing with their poles facing inwards, the housing being supported on a shaft running on ball bearings and connected to the prime mover. The driven member consists of a similar number of permanent magnets arranged with the poles facing outwards, the magnets being mounted and completely enclosed in a non-magnetic and, if necessary, corrosion-resistant housing attached to the internal rotating part of the machine. The two rings of magnets are mounted concentrically with a small gap between their poles in which is interposed the sealing shroud made from *Inconel* or austenitic stainless steel.

The actual pump comprising the impellor casing shaft, etc., can be made from cast iron, bronze, stainless steel, nickel alloys, etc. The bearings which operate in the liquid being pumped, can be made from cast iron, bronze carbon or other suitable materials.

A prototype coupling capable of transmitting about 4.5 h.p. at 1,000 r.p.m. has been made and run at speeds up to 2,400 r.p.m., the sealing shroud being of *Inconel* and capable of withstanding an internal pressure of 50 p.s.i. The power transmitted by the coupling is proportional to the speed, the driving and driven elements rotating at equal speeds without slip. The efficiency is high, the only losses being those due to eddy currents produced in the sealing shroud; by making the shroud of materials with a high electrical resistance, the eddy currents can be kept low and at 1,500 r.p.m. are negligible. As the power that can be transmitted depends upon the gap between the rings of magnets, by increasing the gap at the expense of power capacity a thicker sealing shroud can be fitted and a higher internal pressure can be accommodated.

At the present stage of development the maximum size to which the coupling could be made appears to be about 20 h.p. at 1,500 r.p.m. for a shroud suitable for a working pressure of 50 p.s.i. For smaller powers the shroud can be made suitable for working pressures of 200 p.s.i. and over.

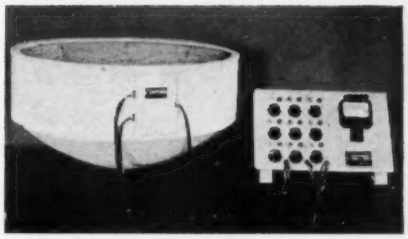
The makers claim that the pump has special applications for difficult gland conditions such as arise in handling corrosive and toxic liquids, operating at elevated temperature, under high vacuum and high suction pressures; temperatures of up to 350°C. will not affect the magnets and the coupling can be used under these conditions.



Glandless pump, showing on the left the solid metal sealing shroud bolted to the pump casing.

Heating mantle for 250-litre vessel

One of a range of heating mantles known as *Isomantles* has been designed for a 250-litre hemispherical stainless-steel vessel. The mantle is fitted with a hole in the base to accommodate the lower outlet from the vessel. The total loading is 8 kw., split up in nine separate circuits which are individually controlled by the nine energy regulators incorporated in the control panel. The appliances are available for both three-phase and single-phase current. The temperature at four various positions of the vessel is measured by thermocouples inserted between the heating surface and the metal vessel, and indicated on the instrument which is calibrated from 0 to 450°C. *Isomantles* ensure good control and clean and efficient operation; any danger of spoiling heat-sensitive material is minimised as the required heat is imparted to the liquid through the whole surface of the vessel covered by the mantle. Makers are Isopad Ltd.



'Isomantle,' 8 kw. for 250-litre vessel, with control panel incorporating temperature indicator 0°C.-450°C.

Fifty-one years in steam

After a working life of more than half a century, eight out of eleven Babcock & Wilcox boilers installed in 1901 in the Bloom Street station of Manchester Corporation are still able to carry load. Originally operating reciprocating engines, they steamed a 10 MW turbine set from 1917 up to early 1952. This having been scrapped, they are 'soldiering on' with the district heating service which has been a feature of this station for more than 40 years.

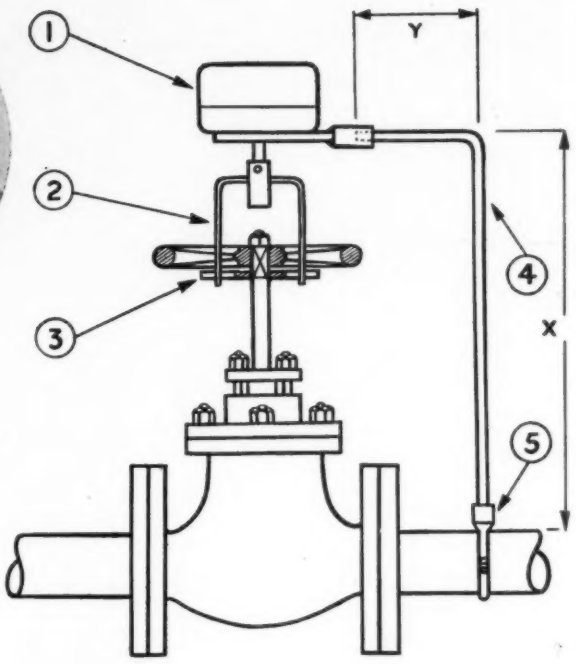
An extension to the Corporation's original station at Dickinson Street, Bloom Street commenced operation in 1901 with four 3,000 i.h.p. Musgrave engines and 11 Babcock & Wilcox boilers. Although the entire boiler installation could comfortably be accommodated in the combustion chamber of a large modern boiler, the capacity of 18,000 lb./hr. was then considered quite a size. With 5,137 sq. ft. of heating surface and 453 sq. ft. of superheater they supplied steam at 160 p.s.i. and 90°F. of superheat, and were fired by Style 4 chain-grate stokers driven by ratchets from cranks attached to underfloor shafting.

Six of the boilers were modified in 1918 (after the turbine was commissioned) to give increased superheat, the grate being lengthened from 8 ft. 6 in. to 10 ft. and the superheat surface increased to 880 sq. ft. Since then some of the grates have been modified to utilise the modern Style 6 link which is shorter and thinner than the original design. All the driving mechanisms are still operating satisfactorily.

Tests taken in 1926 show efficiency figures of 71.4% for the boiler alone and 76.59% for boiler and economiser. The latter, incidentally, were scrapped in 1944.

In spite of the fact that they have operated for a large portion of their working life on Manchester tap-water dosed with a little caustic, the three boilers which have succumbed have done so from external, not internal, corrosion. Unlike the modern header boiler where internal covers tend to tighten under pressure, these boilers are fitted with the old-style external caps which the boiler pressure tends to lift. At some period or other in their long history a weep has been allowed to develop, causing corrosion of the mud box, which has prevented their annual certification.

The future of Bloom Street Station, now vested in the N.W. Division, has not yet been officially announced, but it is obvious that the remaining eight boilers must be allowed to survive a few more years to fulfil long-term contracts for heating steam while final decisions are being made regarding the possibility of installing modern plant for district heating. Some time in the not-too-distant future these old boilers will draw fires for the last time and follow the remainder of the original gear to the scrap heap. If modern plant gives the same long and reliable service as these old-timers it will do well.



Valve position indicator.

(Right) **Fig. 1.**

(Above) **Fig. 2.**

Valve position indicator

Wherever gases, steam or fluids are conveyed through pipelines, valves are provided for stopping or throttling the flow at various times.

Due to costs, not every pipeline can be equipped with a flow meter which would clearly indicate the exact amount of fluid or gas which is being conveyed through this line at a certain time.

It was for this reason, writes R. P. Nuki, M.I.Mech.E., F.R.S.A., that a simple valve position indicator has been developed which shows at a glance whether a valve is closed or how many turns it is open.

The valve indicator arrangement is shown diagrammatically in Fig. 1. It is a very simple device which can be fitted to any standard valve, whether with rising or non-rising spindle. It also makes no difference whether a valve is fitted in the vertical, horizontal or in an inclined position.

The new valve indicator (1) is held by a bracket (4) in a position co-axial with the hand wheel (3) of the valve. A fork piece (2) is inserted between the spikes of the hand wheel and is thereby actuating the indicator following reliably any movement of the hand wheel.

The centre-piece of the fork is coupled to the actual indicator, which indicates on a dial, similar to a clock dial, full turns and parts of turns which the hand wheel has travelled from the 'closed' position. It can be seen in Fig. 2 that two indicator hands are provided, one showing full turns and the smaller one showing parts of turns.

By initially setting the indicator hands to zero when the valve is shut, the hands will automatically follow the progress of opening and then return to the zero position when the valve is closed again. The fully-open position is usually marked on the dial.

The advantages of such indicators are obvious. There is no longer any guesswork which used to be connected with valves. Until now, looking at a valve did not show clearly whether or how many turns a valve was opened. Now it is possible with a single glance at the indicator dial to see at once the degree of opening. It is further possible to set a valve to any degree of opening as required and to re-set it to the same degree of opening to suit process conditions.

New lighting units

An entirely translucent all-glass unit embodying a glass canopy and based on the Holophane system of prisms has been developed by Holophane Ltd. for use in places where good appearance combined with high photometric efficiency are essential.

The units are known as *Lumilux*. The patterns of the prisms are chosen to give a desirable degree of sparkle when the lamp is lit, while the luminance of the fitting as a whole has been controlled to eliminate glare under all normal conditions. A unique feature of this fitting is the combined glass canopy and reflector which forms one moulding and not only eliminates the normal separate canopy but gives added strength to the unit. The diffusing cover glass is clipped to the reflector unit and carries a diffusing pattern of flutes and cross prisms. The reflector may be white or *Correctalite*, while the cover glass is white only. Both glasses are normally velvet-finished.

The glass is supported in the following manner: a rectangular die-casting carrying the lampholder enters a rectangular aperture in the top of the glass and is turned to register across the aperture and is then locked in position by a top cover plate. Two soft pads attached to the die-casting prevent glass-to-metal contact on the load-bearing surfaces.

The units are available in white or *Correctalite* glass, for use with 150 w. or 200 w. filament lamps and are made for chain or tube suspension.

For further information on new plant and equipment please complete the coupon on page 32

Improved Geiger Müller tube

Longer life, larger pulse amplitude and lower operating voltage are the outstanding characteristics of the new Geiger Müller tubes designed by the General Electric Co. Ltd.

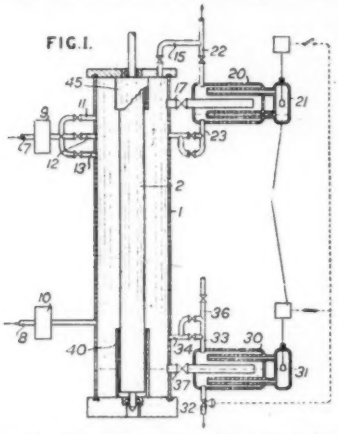
The new tubes have been manufactured on a pre-production scale and are obtainable at short notice. Similar in size and window weight to the existing G.M. 4 tube and with an operating voltage of about 450 v., the 25B7H uses a bromine quenching agent and is known as a halogen-quenched type. Other types of halogen-quenched G.M. tubes will be available later.

Chemical Engineering Invention

MONTHLY SUMMARY OF PATENT CLAIMS

Fluid contacting apparatus

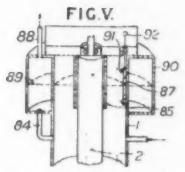
Fluids are brought into contact with each other in a container 1, heavy and light fluids entering from pipes 7, 8, respectively and flowing in counter-current past a smooth rotor 2, and being evacuated



through outlets 37, 15. The container 1 may rotate and the part 2 remain stationary. Sleeves 40, 45, prevent or reduce the shear in the fluid mixture in the vicinities of the outlet ports. Flow controllers 9, 10, are provided on the inlet lines. The heavier fluid may enter through one of the pipes 11, 12, 13. Outlets 17, 37, lead into settling tanks 20 or 30. The former tank has a light fluid outlet 22 and a recirculating line 23 leading back into the container 1. Tank 30 has lines 33, 34, for recirculating lighter fluid and a line 36 to prevent vapour lock in the lines 33, 34. A main outlet 32 is provided, including a valve which is controlled by either of level-control means 21 or 31. The sleeve 40 extends to a level above that of the line 34 and below line 8. The sleeve 45 may be dispensed with.

The heavier fluid entering through the pipe 7 is dispersed into small droplets falling through the lighter fluid which passes upwards. The two or more fluids may include a fluid (liquid gas or powdered material) and a fluid-contacting agent such as acid-reacting substances, basic-reacting substances, salts; reducing, oxidising, halogenating or solutising agents or other materials used in various processes. The sleeve 40 may be raised clear of the bottom of the container 1. It may be spaced from the rotor 2 and may be rotated at a different speed from that of the rotor 2.

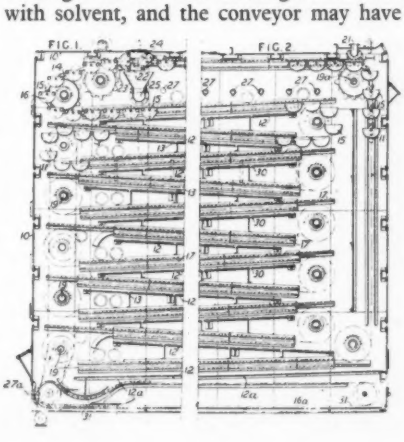
Fig. V shows another modification, wherein a settling tank 90 surrounds the stator opposite the sleeve 85. The withdrawal port 87 may be mounted on a slide 91 operated by means 92 so that withdrawal of the fluid may be made either at, above, or below the interface level 89.



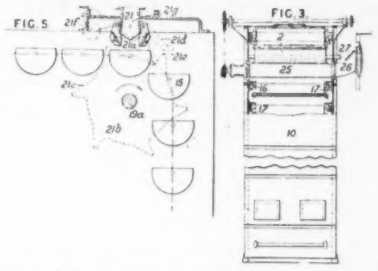
A recirculating line 84 and a light-fluid outlet 88 are provided. The surface of the contact zone, on the periphery of the rotor, may be stepped, curved or tapered. The apparatus may be jacketed to control its temperature and one or more further bearings may be provided for the rotor. Baffles may be provided in the settling tanks and cups formed by sleeves spaced from the rotor. Materials which may be used are listed in the specification.—613,229, *Shell Development Co.*

Solvent extraction plant

In the extraction of soluble matter from solid material the latter travels upwards or downwards in a sinuous path while a solvent (such as water, an aqueous solution or an organic solvent for fats, etc.) is applied to the material at an upper level and drains downwards through the material. The material, as it passes along individual legs or runs of the sinuous path, is subjected several times at intervals to floodings with solvent. The solvent may be passed counter-current to the material to be extracted. The apparatus in which the extraction is carried out may comprise vertically spaced trays or partitions, a conveyor through which the solvent can drain, arranged to travel in a sinuous path along and between the trays or partitions, means for feeding material to be treated on to the conveyor, means for discharging the material after treatment, means spaced along the conveyor for flooding or drenching the material with solvent and means for subsequently discharging or collecting the solvent. There may be intervals for drainage between the flooding of material with solvent, and the conveyor may have



drainage means for the drainage of the solvent through it and on to the tray below. The trays may be apertured or in spaced sections so that the solvent runs from a tray above on to the material on the section of the conveyor below. The supply means for solvent material to be treated, discharge means for the treated material and solvent containing the extracted matter, and the conveyor are arranged so that the solvent flows down-



wards from one section of the conveyor to a section below counter-current to the upward movement of the conveyor. The feeding means for the material to be treated may be provided with a control valve or shutter which is connected with the conveyor mechanism so as to be operated in synchronism with the movement thereof and so as to be opened as a conveyor bucket comes beneath said feeding means and closed during the passage of a gap between neighbouring buckets beneath the feeding means. Means may be provided for collecting sludge from the base of the apparatus and returning it to the conveyor buckets. As shown, crushed nuts or seeds to be extracted are fed by means of a shoot 21, Figs. 2 and 5, in the top of the tall closed casing 10, Figs. 1 and 3, into the long conveyor buckets 15, Figs. 1, 2 and 5, as they pass below it. The discharge of material from the shoot is controlled by valve shutters 21*a*, which are opened for a period as each conveyor bucket comes into position below the shoot. The shutters are operated synchronously with the movement of the conveyor by a cam-wheel 21*b*, keyed on the shaft 19*a*, carrying one pair of the conveyor sprocket wheels. The cam members 21*c*, of the cam-wheel 21*b*, operate one of the shutters 21*a* through an arm 21*d* carrying a cam roller 21*e*. The other shutter carrying the closing weight 21*f* is operated by gearing it to the arm 21*d* through toothed segments 21*g*. After being filled with material from the shoot 21 the buckets 15 attached to the conveyor belt 11, comprising a pair of endless chains 14, between which the buckets are supported in such a manner as to swing freely, pass vertically downwards to the lower part of the machine and then follow a sinuous path upwards and between a

number of inclined trays 12, spaced one above the other, the chains 14 being guided by rollers 16 (Figs. 1 and 3) running in tracks 17 on opposite sides of the trays. As the buckets pass above and along the uppermost tray their contents are flooded with solvent from the perforated pipes 27 spaced comparatively far apart. The solvent, now containing matter extracted from the material in the buckets, drains out through the perforated bottoms of the buckets on to the tray beneath, runs down the tray until it reaches one of the spaced successive gaps 13 in the tray and then flows through the gap on to the material in the moving buckets immediately below. The solvent passes similarly from tray to tray via the buckets of material, extracting more and more matter from the material as it flows downwards counter-current to the path of the buckets.

Finally, the solvent runs on to and down the false bottom 12*a* and floods into the sump 10*a*, from whence it is discharged. After passing beyond the uppermost tray the buckets are tipped by the cam elements 23 and 24 and discharge the spent material into the hopper 22, from which a worm 25 feeds the material to and through a discharge duct 26. A chain scraper 31, driven from one of the sprocket wheel shafts 19, scrapes the sludge settling on the bottom of the casing to one end, from where it can be returned to the conveyor buckets via pipe 27*a*. The machine may be provided with ten trays each having an average of, say, four spaced solvent discharge gaps or slots, the material thus being subjected to a large number of alternate floodings and drainings during its passage through the extraction.—618,780, *J. Bibby & Sons Ltd. and J. E. Bibby.*

Advances in catalysis

IN this volume* the editors continue with their design for the presentation of new information on catalysts, catalytic reactions and related fields.

To the chemical engineer and industrial chemist the section by H. Pichler on 'Twenty-five Years of Synthesis of Gasoline by the Catalytic Conversion of Carbon Monoxide and Hydrogen' will be of the greatest interest. It is 25 years since Fischer and Tropsch reported their discovery that carbon monoxide and hydrogen in the presence of certain catalysts react to give a whole range of aliphatic hydrocarbons. Pichler gives an excellent review of the immense effort and ingenuity which have gone into research and development to the present day, culminating in the American Hydrocol plant designed to process 64 million cu.ft./day of natural gas as raw material.

The possibilities of the Fischer-Tropsch synthesis have naturally excited interest in Great Britain because of our lack of indigenous supplies of liquid fuels. However, in face of our serious shortage of fuel of any kind, it seems doubtful whether a process which converts half the fuel content of the raw material to carbon dioxide or to water could be tolerated for years to come.

The basic research work on the mechanism of the reaction has been considerable, but the position is by no means clear; in particular the role of carbides of the catalyst metals is still uncertain. The way in which technical development outstrips fundamental knowledge seems to be a common feature of catalytic processes.

Volume III contained two excellent articles on the catalytic cracking of hydrocarbons (see CHEMICAL AND PROCESS ENGINEERING, 1952, **33**, (4), 189). The article in this volume by Hansford on 'Chemical Concepts of Catalytic Cracking' would appear to add little, and there are very few references to work not already previously reviewed.

The 'Structure and Sintering Properties of Cracking Catalysts and Related Materials,' by H. E. Ries, brings out the two ways in which catalysts may deteriorate: by poisoning or by structural deactivation. In the first the activity of the catalyst decreases more rapidly than its surface area, while in the second, activity and surface area decrease in proportion. The latter is of particular concern in fluid-bed catalytic cracking where burning and steaming are essential features of catalyst regeneration. The author describes the way in which adsorption isotherms may be used to study the decline in surface area of both natural and synthetic cracking catalysts, and refers to the use of electron microscopy in the study of the structure of natural porous catalysts such as diatomaceous earth.

G. D. Halsey reviews 'The Role of Surface Heterogeneity in Adsorption' and concludes that in the case of chemisorption the position is controversial. It appears that study of adsorption on single crystal faces, where no heterogeneity should be possible, will help to resolve the matter.

'The Theory of Physical Adsorption,' by T. L. Hill, reviews some aspects of the statistical thermodynamical theory of physical adsorption, and the subject receives a mathematical treatment designed for the benefit of experimentalists in this field.

The remaining four articles deal with catalytic effects in homogeneous media which, the editors point out, are in some respects less complicated than heterogeneous catalytic reactions. However, the articles themselves would indicate that this optimism is by no means fully justified.

'Acid-base Catalysis and Molecular Structure,' by R. P. Bell, gives an excellent review of the subject, dealing with the laws of acid-base catalysis, the molecular mechanism and reaction velocity. Mention is made of the use of deuterium in the elucidation of both the course and of the velocity of catalysed reactions.

In the 'Decomposition of Hydrogen Peroxide by Catalysts in Homogeneous Aqueous Solution,' by J. H. Baxendale, it is shown that this field of investigation is by no means worked out, although the subject was first examined a century ago. The catalytic decomposition of hydrogen peroxide is of increasing technical importance now that high-strength material is available for chemical purposes and as a 'fuel' for rocket propulsion.

The 'Free Radical Mechanism in the Reactions of Hydrogen Peroxide,' by J. Weiss is of interest in giving the background to the use of hydrogen peroxide and other per compounds as catalysts for the polymerisation of vinyl compounds.

The last article on 'Specific Reactions of Iron in some Haemoproteins,' by P. George, discusses the relationship between biocatalysis by the iron-containing haemoproteins and more 'normal' catalytic effects.

P. J. GARNER, B.A., PH.D., F.INST.PET.

**Advances in Catalysis.* Edited by Frankenburg, Komarewsky and Rideal. Vol. 4. Academic Press, 1952. Pp. 457, including index. $9.50.

Size Reduction

(*Concluded from page 12*)

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44M. F. Dufour and J. B. Chatelain, *Mining Engng.*, 1952, **4**, 262.

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Contributions

THE EDITOR *welcomes practical articles and notes on chemical engineering and industrial chemical subjects. Address such material to* THE EDITOR, CHEMICAL & PROCESS ENGINEERING, *Stratford House, 9 Eden Street, London, N.W.1.*

World News

EUROPE

Chemical output down but engineering industries prosper

A continuing decline in economic activity in most of Western Europe is noted in the latest *Economic Bulletin for Europe* published by the United Nations. Each industry is surveyed in the *Bulletin* which, in discussing chemicals, states that here, too, output is declining in most countries. With the recovery in artificial textiles during the summer, however, some improvement may be expected, particularly in the United Kingdom, the *Bulletin* suggests.

However, in contrast with other industries, the engineering industries 'continued to prosper in the second quarter, owing to rearmament, continued big demand from overseas countries and increased sales of motor vehicles.' The progress of the engineering industry was particularly striking in France, Western Germany and Austria. The United Kingdom made only slight progress, owing to the shortage of steel. In the Scandinavian countries, the stagnation in the engineering industry is mainly due to inadequate export demand.

Total steel production in Europe, not counting the Soviet Union (where an official statement in October put production in 1952 at 12% above 1951), during the first half of 1952 was 9% higher than in the first half of 1951 and, according to the *Bulletin*, the improvement 'is likely to become more pronounced as time goes on.'

GREAT BRITAIN

Soluble nylon

Development quantities of a polymer known as 'Nylon Soluble Polymer Type CA,' which is soluble in alcohol/water mixtures, are being made by I.C.I. From these solutions, films and coatings can be produced which have good temperature and abrasion resistance, are tough and very permeable to water vapour. These properties fit the films for varied uses as adhesives, and as coatings for monofilaments and for textiles.

The polymer has also an important part to play as a textile finishing agent, a grade known as *Calaton CA* having been developed for this purpose. These polymers, chemically different from those used in the production of textile fibres and monofilaments, have been available in America for some time, and a number of interesting applications have been developed.

Obituary

We regret to record the death of Mr. Eric Bradburn Read, chairman of Reads Ltd., drum manufacturers. He was born on May 4, 1899, the son of Mr. W. A. Read, of Brierfield, Little Sutton. He was educated at the Leas School, Hoylake, and subsequently at Marlborough College. He was called up towards the end of World War I and served as a captain in the Royal Artillery. At the conclusion of the war he was in the Army of Occupation in Germany for some time. Shortly after he left the Army he joined Reads Ltd., founded by his grandfather, Mr. Robert Read, in 1869. Following on the retirement of the late Mr. John W. Mann in 1942, he became chairman of the company, which position he occupied until his last illness.

Fumaric and succinic acids

Fumaric and succinic acids have, for many years, been imported from the U.S.A. and Europe. A small plant, erected by L. Light & Co. Ltd., is now in production near Slough, Bucks, and is producing 1-cwt. lots of these acids.

NORWAY

Heavy-water production

Bjarne Eriksen, director-general of Norsk Hydro, Norway's largest chemical concern, has issued a statement about his company's manufacture of heavy water. Norsk Hydro, said the statement, has been producing heavy water for laboratory experiments ever since 1934, and deliveries of heavy water to laboratories all over the world are still going on. Apart from these routine deliveries, however, Norsk Hydro has since the war also produced heavy water in considerable quantities for uranium reactors. Since the war the company has supplied heavy water for experimental reactors in Norway, France and Sweden, and is at the moment making heavy water for delivery to Great Britain. The statement went on: 'Heavy water has played an important role in the work of developing atomic energy. . . . Originally it was widely believed that the importance of heavy water would chiefly be confined to experimental uranium piles with small energy production. Subsequent developments have shown that piles using heavy water as a moderator can probably also play an important role in the industrial exploitation of atomic energy. . . . Heavy water must today be regarded as an important raw material which eventually can play an important role in the generation of power for industry. This application is concerned solely with peaceful industrial purposes. It is desirable to do all in our power to operate the production of heavy water in Norway as efficiently as possible, as Norway is still the sole supplier of heavy water on the European market. For this reason it has been found advisable to treat its production in the same way as any other chemical manufacture, without any regulations for secrecy. In view of the requirements of our own Institute for Atomic Energy, as well as the requirements of industrial atomic reactors elsewhere in Europe, an increase in Norway's production of heavy water is desirable. The possibility of this will be examined. For the moment, however, no concrete plans exist.'

FRANCE

Dye makers to re-equip and expand

The Compagnie Francaise des Matieres Colorantes, a leading French dye producer, is working out an extensive modernisation and expansion scheme. The aim is to mechanise existing workshops, add new ones and promote further research. It is designed to enable France to keep pace with international dye industries. Finance for the scheme will be raised privately, although the Government owns 10% of the company's shares.

The French dye industry already makes a fairly comprehensive range of products. However, certain lacquers and special textile dyes still have to be imported. In 1951, when domestic consumption of dyestuffs reached a peak of 12,500 tons, imports totalled 2,600 tons. The output at home, also a record at 16,000 tons, permitted exports of 5,700 tons. However, final figures for 1952 are expected to show falls in consumption, imports and exports. Consumption and imports will reflect the difficulties experienced by the textile, leather and dye industries. Exports, despite Government aid, will reflect similar conditions overseas and increasing competition, notably from Germany.

New plastics plant

Monsanto Chemical Co., U.S.A., have formed a new jointly-owned French company in association with Compagnies Réunies des Glaces et Verres Speciaux de la France. This new company, La Société Monsanto-Boussois S.A., will produce plastic materials, including polystyrene moulding compounds, which will be made by processes owned by Monsanto, and developed by its plastic division at Springfield, U.S.A.

Engineering of this plant will start immediately and construction will follow at Wingles, near Lens, the site of an existing glass manufacturing plant owned by the French parent company. Operations will start before mid-1953.

AUSTRALIA

More agricultural chemicals to be made

A plan to increase the production of chemicals for agricultural use which would help to expand Australia's food output has been announced by Imperial Chemical Industries of Australia and New Zealand. The company will spend £A500,000 in increasing the output of present chemicals and the manufacture of new ones, in the establishment of formulation plants for agricultural chemicals and also in research. A modern biological laboratory is to be erected.

JAPAN

U.S. urea plant for Japanese firm

The urea plant engineered and designed by Chemical Construction Corporation for Sumitomo Chemical Co. Ltd. at Niihama, Japan, is now in operation and is to be expanded to triple its present capacity. The plant uses a new high yield process developed by Chemico and produces both plastic and fertiliser grade urea.

Sumitomo, a major Japanese chemical company, has been an important urea producer for many years.

Fertiliser exports subsidised by home market

Japanese ammonium sulphate producers, under-bid in several recent international tenders, have worked out a new approach to the problem. Under the scheme, low tenders—even if involving a loss—are submitted. These losses are offset by profits on sale to domestic consumers.

In a recent Mutual Security Agency tender for purchases of fertiliser for India, Japanese producers are reported to have quoted around $46 to $47.50/ton f.o.b. This was equivalent to around 630 yen, delivered dealers, per bag of 10 kans. The actual domestic price is around 900 yen per 10-kan bag.

An earlier plan to push exports, shelved under pressure from the Fair Trade Commission, involved the setting up of a joint export company by Japanese ammonium sulphate manufacturers.

Sulphur output and exports

Japanese rayon manufacturers have been alarmed by recent good export business in Japanese sulphur which, coupled with the slow expansion of mining facilities, is likely to cause a domestic shortage of sulphur. A spokesman of the Japan Synthetic Textile Association said it had made representations to the Ministry of International Trade and Industry to curb further exports of sulphur from Japan.

According to the spokesman, sulphur production in Japan during the current financial year (from April 1952 to March 1953) had originally been estimated at 225,000 metric tons, but actual output during the first half of the financial year amounted to only 86,500 tons. Production in the latter half of the period is now estimated at around 100,000 tons, making the total for the year less than 190,000 tons.

On the other hand, domestic sulphur consumption during the current financial year had originally been estimated at 149,000 tons. However, consumption by Japan's synthetic textile and pulp manufacturing industries, which account for nearly 90% of total sulphur consumption in the country, has widely surpassed the original estimate, and total domestic consumption during the current financial year is now estimated at 160,000 tons.

Meanwhile, sulphur exports from Japan have been progressing smoothly and bank certifications of export declarations during the first half of the current financial year totalled 43,000 tons, against 75,000 tons planned for the whole year.

According to the Japan Chemical Industries Association, actual export shipments of sulphur from Japan during the first half of the current financial year totalled 19,000 tons, while a total of 20,000 tons, including 17,000 tons for Australia and 3,000 tons for New Zealand, has already been shipped since the start of the second half of the year. The 20,000 tons so far shipped in the second half of the current financial year represents nearly 50% of the total sulphur export target of 41,000 tons for the period.

Export prices of Japanese sulphur have been around 39,000 yen/ton, c.i.f., compared with domestic prices ranging from 30,000 to 32,000 yen/ton, ex-works. Some of the sulphur mines have already suggested that domestic prices be raised to 33,000 yen/ton, which is unacceptable to the synthetic textile industry in view of the recent heavy slump in Japanese rayon trade.

The Leonard Hill Technical Group

Articles published in some of our associate journals in the Leonard Hill Technical Group this month include:

Manufacturing Chemist — Manufacture of Adhesives; Recent Advances in Pharmacognosy; Progress Reports on Chemotherapy, Fertilisers and Cosmetics.

Paint Manufacture—Anti-fouling Paints for Aluminium Alloys used in Ship Building; The Effect of Phosphate Coating; The Testing of Impregnating and Insulating Varnishes—2; The Qualities of 'Epoxide' Resins.

Petroleum—Manchester Oil Refinery Expansion; Grangemouth Development; Isle of Grain Refinery; Progress at Fawley.

Atomics—Radiochemistry at Teddington; A Review of Scintillation Counting.

World Crops—World Agricultural Production, 1951/1952; The Volga-Don Irrigation Project.

Building Digest—Wide Span Roofs: Recent Developments in Construction, Insulation and Cladding; Steel Grillage Components for the Prefabricated Roof; Prestressed Hangars at London Airport.

Muck Shifter—Reclamation of the Zuyder Zee; Improved Rolling Stock for Constructional Work; A Unique Draining Team in Lincolnshire.

PAKISTAN

Belgians to engineer fertiliser factory

Under a contract signed recently in Karachi, the Belgian company, Union Chimique Belge, is to supply technical advice for the erection and initial operation of a nitrogen fertiliser factory in Pakistan which is to be operated by the Pakistan Development Corporation. It will cost the equivalent of 800 million Belgian francs and have an initial annual capacity of 50,000 tons of ammonium sulphate. It will be situated at Daudkhel, near Mari Indus.

Technical processes for which installations are to be provided include gasification of coal under pressure, extraction of nitrogen from the atmosphere for the production of ammonium, and the production of ammonium sulphate from ammonia and gypsum.

KENYA

Oil refinery at Mombasa

An announcement in the *Kenya Official Gazette* states that the Kenya Government intend to take over 2,000 acres of land on the south mainland of Mombasa for the purpose of the building of a giant oil refinery at an estimated cost of between £40 and £50 million and with an estimated output of about 6 million tons p.a. of petroleum products. Such a project would be the biggest development scheme ever known in East Africa and would involve an expenditure considerably in excess of that of the groundnuts scheme. Later, a statement was issued saying that such a project was indeed under examination, a preliminary survey had been carried out and a site had been selected; details of the scheme were being worked out, but a final decision in regard to the erection had not yet been reached.

PHILIPPINES

Salt production plans

It is officially announced that the Philippine Cabinet has approved the proposal of the Philippine Salt Development Syndicate to go into large-scale production of salt in the Philippines, both for domestic use and for export. Cabinet approval was sought by this company for two reasons: that it will have the assistance of Japanese financing and technical knowledge; and that it will need Government permission to export its products to countries outside the Philippines, especially Japan. Suitable sites have already been found and a team of Japanese experts is to examine them.

The Export Control Committee advised the Cabinet that it had no objection to the proposal to export the products of the new firm in any quantity.

CANADA

Nylon plant

Work on the $25-million plant being built by Canadian Industries Ltd. at Maitland, Ontario, for the manufacture of adipic acid and hexamethylene diamine, essential in the production of nylon, is reported to be progressing satisfactorily. Completion of the intermediates plant at Maitland in mid-1953 will make Canada's nylon industry entirely self-sufficient.

Saskatchewan potash deposits

Discovery and development of potash deposits near the Saskatchewan centres of Vera and Unity has opened a new phase for prairie agriculture. The full extent of the Vera-Unity deposit has not yet been determined, but exploratory drilling indicates it might extend over an area of

250 sq. miles in varying thicknesses up to 11 ft. The ore is known as sylvanite and contains a high concentration of potassium chloride, which is a readily soluble salt. The Western Potash Corporation Ltd. has already spent about $1 million on exploratory drilling for commercial development.

At the present time, Canada produces scarcely any mineral potash and imports almost $4 million worth p.a. from the United States and Europe.

UNITED STATES

Plastic air filter

An air filter said to remove 'at least 400%' more fine dirt from forced-air heating and air-conditioning systems than other filters on the market has been announced by the Goodyear Tire & Rubber Co. Named *Pliotron*, the product is filled with shredded plastic containing a 'lifelong electrostatic charge.' The plastic traps and holds the finest pollen, soot and dust particles as a magnet attracts metal.

Goodyear claims that *Pliotron* filters can be installed in existing forced-air systems and are easily cleared in a few minutes by rinsing in clear water. The company is in full production and has started national distribution through heating and air-conditioning sales outlets in all major trade areas.

The units are available in four sizes at retail ranging from $11.75 to $13.75.

Ore concentration process

International Minerals & Chemicals Corporation has announced a new ore beneficiation process applicable to potash and phosphates and to many other types of ores. International is to build a new and larger pilot plant at Carlsbad, New Mexico, to treat by this method semi-commercial quantities of potash. The method, known as the Lebaron-Lawver process, is dry, using neither reagents nor water, and continuous.

German coal gasification process

A new German process for gasifying pulverised coal, now ready for commercial application, is expected to answer the increased demand for coke-oven gas in Germany, according to a report by Dr. Kurt Traenchner, assistant director of the Ruhr-Gas Co., in Essen, developers of the process. The report, read before the annual meeting of the American Society of Mechanical Engineers in New York, said that results of the process exceeded those of conventional gas producers gasifying coke.

Polyester film plant

The du Pont Co. is planning a $10 million plant at Circleville, Ohio, to produce its new plastic material, *Mylar*. The product is a polyester film and is chemically similar to du Pont's new synthetic fibre, *Dacron*, it is stated. However, whereas *Dacron* is spun, the new material is produced in continuous sheet form.

The company believes its main use will initially be as insulating material in cable, coils and electrical apparatus. Other applications are forecast in the packaging fields.

The new plant to produce *Mylar* is expected to go into operation early in 1955. At the moment the material is being made experimentally at the company's Yerkes Research Laboratory in Buffalo.

Dacron is du Pont's version of the I.C.I. fibre, *Terylene*, for the manufacture of which a new plant is being built at Wilton, Yorkshire (see CHEMICAL & PROCESS ENGINEERING, November 1952, pp. 599-601).

Plastic coating for fan blades

A liquid, quick-drying plastic, has been developed by the Metal Products division of Koppers Co., Inc., working in conjunction with Tennessee Eastman Co., and is being used to coat the blades of fans used in industrial cooling towers. The new plastic, called *Aeroloid*, has been adopted for use on industrial fans made by Koppers, which range from 4 to 20 ft. in diameter. It has an acetate-butyrate base and certain other chemicals which made it fire-resistant. It is claimed that *Aeroloid* dries to a satin finish which is also resistant to moisture, abrasion and corrosion.

The use of the new plastic was made possible only by the development of a special primer compatible with the laminated wood of the fans and also with the coating itself.

HUNGARY

Steel production plans

Furthering the production of high-quality steel was the main objective of a two-day conference of the Hungarian Mining and Metallurgical Association, held in Budapest recently. This was stated by Mr. István Kossa, Minister of Metallurgy and Engineering, when addressing the meeting.

The Government had given first place to investments in the iron and steel industry, he said, because it appreciated the importance of metallurgy in the national economy. Hungarian steel production is being raised from 860,000 tons in 1949 to 2,200,000 tons in 1954. The construction of the Stalin iron and steel works and improvements to the Diósgyör, Ózd and Mátyás Rákosi steel works were examples of this interest.

All Soviet experience in steel production was now at the disposal of Hungarian technicians, added the Minister. There was also close collaboration with the equivalent industries in the other people's democracies.

The second day of the conference was taken up with lectures and discussions on economy in the use of alloys in steel, and the use of chrome and manganese in preference to nickel and molybdenum.

Forthcoming Meetings

Institution of Chemical Engineers

January 13. Symposium on 'Bursting Discs,' 3.20 p.m., Geological Society, Burlington House, London, W.1.

Chemical Society

January 14. 'The Use of Lithium Aluminium Hydride in Organic Chemistry,' by Dr. D. Twomey, 7.45 p.m., University College, Upper Merrion Street, Dublin. Joint meeting with Institute of Chemistry of Ireland.

January 19. 'Resonance,' by Prof. C. A. Coulson, 5 p.m., University College, Leicester.

January 22. 'Discoveries among Conjugated Macrocyclic Compounds,' by Prof. R. P. Linstead, 7.30 p.m., Burlington House, Piccadilly, W.1.

January 22. 'Biogenesis of Carotenoids,' by Dr. T. W. Goodwin, 7 p.m., Chemistry Department, The University, Bristol. Joint meeting with the R.I.C. and S.C.I.

January 22. 'Chemical Aspects of Drug Metabolism,' by Prof. R. T. Williams, 5 p.m., Chemistry Lecture Theatre, The University, Liverpool. Joint meeting with the R.I.C., S.C.I. and the British Association of Chemists.

January 23. 'Usnic Acid and its Derivatives,' by Prof. A. Robertson, 4.30 p.m., Chemistry Lecture Theatre, The University, Edgbaston, Birmingham 15.

January 23. 'Chemical Reactions Induced by Nuclear Radiations,' by Prof. F. S. Dainton, 5 p.m., New Chemistry Building, The University, Southampton. Joint meeting with the R.I.C.

January 29. 'Progress in Hydrogen Bond-chemistry,' by Prof. L. Hunter, 7.15 p.m., Gloucester Technical College. Joint meeting with the R.I.C. and S.C.I.

January 29. 'Experiments with Radioactive and Stable Isotopes,' by Prof. F. S. Dainton, 4.45 p.m., The University, Nottingham.

Society of Chemical Industry

January 8. 'Industrial Oxygen,' by D. Ambrose, 7.15 p.m., Nottingham and District Technical College, Nottingham.

January 9. 'Cellulose Ethers and their Applications,' by W. A. Caldwell, 7.15 p.m., Royal Technical College, Glasgow.

January 12. 'Recent Experiments on the Friction and Adhesion of Solids,' by G. W. Rowe, 7 p.m., Chemistry Lecture Theatre, The University, Leeds.

January 15. 'Vitamin B_{12} and Related Factors,' by E. Lester Smith, 7.30 p.m., Heriot Watt College, Chambers Street, Edinburgh.

January 15. 'The Fine Chemicals Industry,' by H. G. Dickenson, 7 p.m., College of Further Education, Widnes, Lancs.

January 21. 'Analysis of Metals by Spectroscopy,' by Dr. A. C. Menzies, 6.30 p.m., University College, London, Gower Street, London, W.C.1. Joint meeting with the Institute of Metals and the R.I.C.

January 23. 'Seeing, Electrometrically, How Chemical Reactions take Place,' by H. T. S. Britton, 5 p.m., Technical College, Plymouth.

January 28. 'Luminescence in Solid Materials,' by W. P. Doyle, 7.45 p.m., Department of Chemistry, Trinity College, Dublin.

January 28. 'Instrumentation in a Chemical Factory: *p*H Measurement and Control,' by J. W. Broadhurst, 7.30 p.m., Harris Institute, Preston. Joint meeting with the R.I.C.

February 2. 'The New Wool-like Fibres,' by Dr. D. Traill, 6.30 p.m., Chemical Society, Burlington House, Piccadilly, W.1. Joint meeting with Plastics and Polymer Group.

Crop Protection Panel

January 19. 'Biochemistry of Schradan,' by Dr. B. A. Kilby, 5.30 p.m., Chemical Society, Burlington House, Piccadilly, W.1.

Chemical Engineering Group

January 20. 'The New Treatment Plant of the Colne Valley Sewage Board,' by J. Griffiths, 5.30 p.m., Geological Society, Burlington House, Piccadilly, W.1.

Corrosion Group

January 20. 'The Electrochemical Behaviour of Metals and Corrosion,' by M. Pourbaix, 6.30 p.m., Chemical Society, Burlington House, Piccadilly, W.1.

Fine Chemicals Group

January 9. 'New Routes to Cortisone,' by Prof. E. R. H. Jones, 7 p.m., London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

Food Group

January 21. 'The Preservation of Natural Colours and Flavours in Food,' by V. L. S. Charley, 6.30 p.m., Mason Theatre, The University, Edmund Street, Birmingham 3.

January 28. 'Food and the Future—2: Present Methods of Attack on the Problem,' by G. A. C. Herklots and J. Yudkin, 6.30 p.m., Chemical Society, Burlington House, Piccadilly, W.1.

Road and Building Materials Group

January 15. 'The Use of Rubber in Bituminous Road Surfaces,' by A. R. Smee and L. Mullins, 6 p.m., The Building Centre, Store Street, Tottenham Court Road, London, W.C.1.

Fertiliser Society

January 22. 'Manufacture of Triple Superphosphate,' by J. J. Porter and J. Frisken, 2.30 p.m., Lecture Hall, Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1.

Institute of Fuel

January 27. 'Efficiency of Domestic Space-heating Appliances using Solid Fuel,' by L. L. Fox, 5.30 p.m., Institution of Mechanical Engineers, Storey's Gate, London.

February 6. 'Ash and Clinker in Practice—Handling and Disposal,' by W. G. Marshall and C. W. Pratt; 'Ash and Boiler Efficiency,' by Dr. A. C. Dunningham; 6 p.m., South Wales Institute of Engineers, Park Place, Cardiff.

February 6. 'Collection of Dust from Flue Gases,' by J. C. Cleeves, 7 p.m., Royal Technical College, Glasgow.

Institute of Metals

January 13. 'The Metallurgical Problems arising from Stratospheric Flight,' by Major P. L. Teed, 6.30 p.m., University College, Metallurgy Department, Singleton Park, Swansea.

January 21. 'Alloys Resistant to Oxidation and Creep at High Temperatures,' by S. J. Kennett, 6.30 p.m., Liverpool Engineering Society, The Temple, Dale Street, Liverpool.

February 4. 'Some New Laboratory Techniques,' by Dr. F. Ashworth, F. G. Haynes and J. Johnson, 6.30 p.m., Engineer's Club, Albert Square, Manchester.

February 5. 'The Continuous Casting Processes,' by Dr. E. Scheuer, 7.15 p.m., Chemistry Department, The University, Leeds 2.

Institute of Metal Finishing

January 23. 'Observations on Electroplating Research and Flatware Manufacture in the U.S.A.,' by Dr. G. E. Gardam, 7.30 p.m., Grand Hotel (Fitzwilliam Room), Sheffield.

February 3. 'Properties of Electrodeposits in Relation to Engineering Requirements,' by R. A. F. Hammond, 6.30 p.m., James Watt Memorial Institute, Great Charles Street, Birmingham 3.

Institute of Works Managers

January 14. 'Industrial Aspects of River Control and Pollution Prevention, based on Watershed Areas,' by C. Lea, 7.30 p.m., Vane Arms Hotel, Stockton-on-Tees.

January 20. 'Line Flow Production in Industry,' by F. G. Woollard, 7 p.m., Grand Hotel, Birmingham.

January 26. 'Activities of P.E.R.A.,' by Dr. G. F. Galloway, 7.30 p.m., Franklins Gardens Hotel, Northampton.

Institute of Petroleum

January 14. 'Methods of Hydrocarbon Type Analysis,' by H. C. Rampton, 5.30 p.m., 26 Portland Place, London, W.1.

January 28. 'Geophysics—Its Problems and Trends,' by D. T. Germain-Jones, 5.30 p.m., 26 Portland Place, London, W.1.

January 20. 'The Use and Character of New Chemicals from Petroleum,' by Dr. E. S. Paice, 6.30 p.m., The Engineers' Club, Albert Square, Manchester.

Royal Institute of Chemistry

January 8. 'Science and Domestic Heating,' by R. A. Mott, 7.30 p.m., White House Hotel, Kingston-upon-Hull.

Hull Chemical and Engineering Society

January 27. 'Silicones and their Industrial Uses,' by N. H. Collings, 7.30 p.m., Church Institute, Kingston-upon-Hull.

Incorporated Plant Engineers

January 13. 'Oxy-acetylene Processes Applied to Industry,' by R. Wilbourne, 7.15 p.m., The Engineers' Club, Albert Square, Manchester.

Manchester Literary and Philosophical Society

Chemical Section

January 28. 'Sulphur,' by C. F. Young, 5.45 p.m., Portico Library, Mosley Street, Manchester.

Royal Society of Arts

January 21. 'Plant Hormones,' by S. C. Harland, 2.30 p.m., John Adam Street, Adelphi, London, W.C.2.

CHEMICAL & PROCESS ENGINEERING

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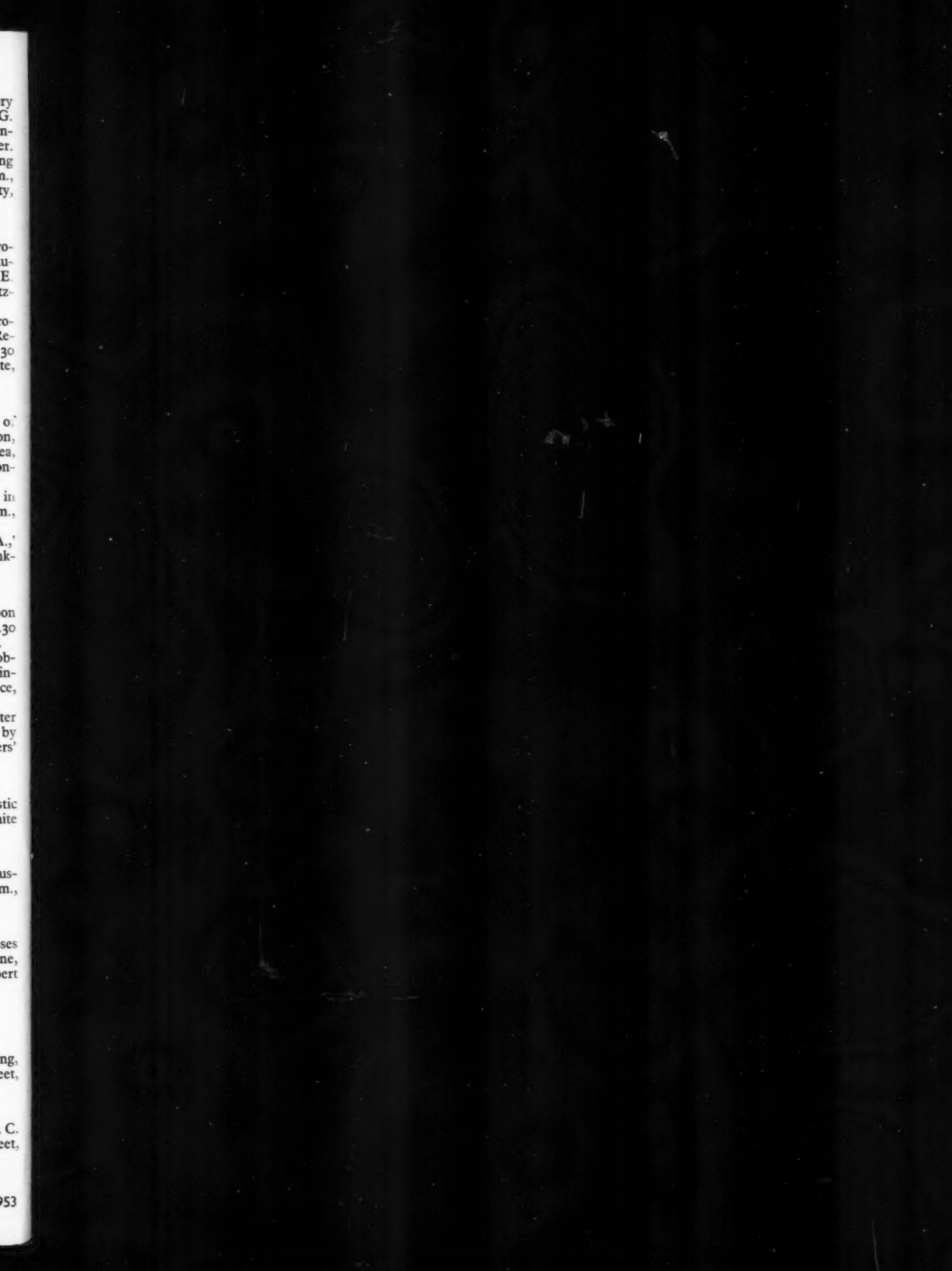
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